COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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January, 1951

Looking up into furnace of No. 5 unit at Port Washington Station: see page 39

The Electrical Industry in 1950 ▸

Steam Power Activity and Trends ▸

By-products Used as Fuels ▸

C-E REHEAT BOILERS

CLERMONT STATION

THE CINCINNATI GAS & ELECTRIC COMPANY

THE C-E Unit shown here is now in process of fabrication for the Clermont Station of The Cincinnati Gas & Electric Company at Cincinnati, Ohio.

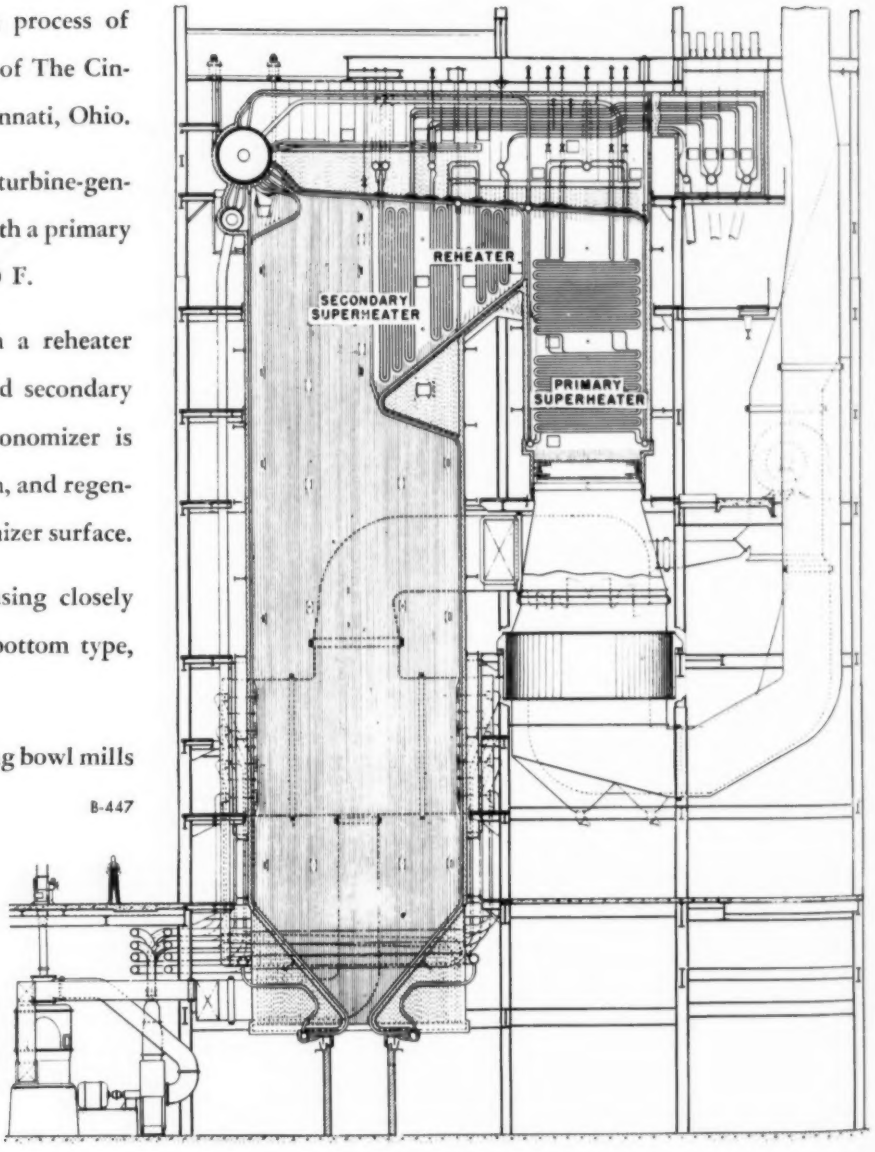
It is designed to serve a 100,000 kw turbine-generator at a throttle pressure of 1450 psi with a primary temperature of 1000 F reheated to 1000 F.

The unit is of the radiant type with a reheater section located between the primary and secondary superheater surfaces. A finned tube economizer is located below the rear superheater section, and regenerative type air heaters follow the economizer surface.

The furnace is fully water cooled, using closely spaced plain tubes. It is of the basket-bottom type, discharging to a sluicing ash hopper.

Pulverized coal firing is employed, using bowl mills and tilting, tangential burners.

B-447



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COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

Vol. 22 **No. 7**

January, 1951

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COMBUSTION publishes its annual index in the June issue and is indexed regularly by Engineering Index, Inc.

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Published monthly by COMBUSTION PUBLISHING COMPANY, INC., 200 Madison Ave., New York 16

A SUBSIDIARY OF COMBUSTION ENGINEERING-SUPERHEATER INC.

Joseph V. Santry, President; Charles McDonough, Vice-President; H. H. Berry, Secretary and Treasurer

COMBUSTION is sent gratis to engineers in the U. S. A. in charge of steam plants from 500 rated boiler horsepower up and to consulting engineers in this field. To others the subscription rate, including postage, is $3 in the United States, $3.50 in Canada and Latin America and $4 in other countries. Single copies: 30 cents.
Copyright 1951 by Combustion Publishing Company, Inc.
Publication Office, Easton, Pa. Issued the middle of the month of publication.

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Editorials

Delays under Nationalized Power Supply

Red tape incident to construction of electric generating stations under the nationalized power supply in Great Britain is cited in *Engineering* of November 24 as one of the major factors in the delay in acquiring much-needed expansion in capacity. It is pointed out that to secure approval of a site plans must first be submitted to the Ministry of Fuel and Power where examination is made for conformity to certain regulations. They must then be approved successively by the Ministry of Town and Country Planning, the Ministry of Agriculture, the Air Ministry, the Ministry of Civil Aviation and by the local authorities concerned. If objection arises within any of these bodies public hearings are held. Resulting modifications are likely to involve futher delay. Finally, the Royal Fine Arts Commission must pass upon the architectural features of the station.

The net result, to quote the editorial, is that "it is not unusual for two years or more to elapse between the selection of a site and final permission to occupy it." To this must be added the necessary construction time. Is it any wonder that five years or more after World War II British industry is still being handicapped by power cuts?

This is in marked contrast to the postwar power construction in the United States by the privately owned electric utilities.

Regional Hydro Development

Publication of the 445-page first section of a study made by the President's Water Resources Policy Commission reveals an apparent determination on the part of the Federal government to extend the T.V.A. concept to at least nine other great river basins. At the time the report was released, President Truman had the following comment to make: "Plans for water development can no longer be made successfully by individual interests, whether they are private or public, whether they are local, state or Federal."

One may wonder what will be the ultimate consequence of a policy of considering whole river basins instead of "one-river, one-plan" projects. It would appear to promote a monopoly for Federal water-power projects because of the power of Federal agencies to veto the selection of hydroelectric sites. This comes under a proposal which states, "future licenses for new non-Federal water-power developments should be issued only with the joint consent of the Federal agencies responsible for power in basin programs."

The newly issued report ignores most of the recommendations of the "National Water Policy Study" made by the Engineers Joint Council in June 1950. One of the major premises of the latter was that water resources development should be undertaken, wherever feasible, by local enterprise, governmental or private. This is far removed from the concept of full river-basin development now advocated.

There are many who will agree with the contention of James W. Parker, president of the Detroit Edison Co., that the report constitutes "one more expression of hostile attitude toward independent enterprise."

Gas Turbine Progress

Experience gained in military aviation during World War II contributed greatly to progress of the gas turbine in this country, and the year just closed has seen this type of prime mover placed in service at two relatively small New England central stations. Also, more than a year's satisfactory service was experienced at the Belle Island Station of the Oklahoma Gas & Electric Company. The largest of these units is rated at five thousand horsepower and the fuel includes both oil and natural gas.

A two thousand horsepower industrial gas turbine, operating on natural gas, has been engaged in gas-line pumping service since last May and other units of larger capacity for such service are under development.

In the railway field, following some eighty thousand miles of operation by a test unit, the Union Pacific has just ordered ten such locomotives for its freight service. These will be rated at forty-five hundred horsepower each and will operate on Bunker C oil.

Inasmuch as the gas turbine is similar in principle to the power plant of a jet plane, without the jet effect, it may be assumed that experience gained in our present defense program may add further to development of the gas turbine, especially with regard to the behavior of metals at high temperatures.

The Electric Industry in 1950

Fabian Bachrach

Louis V. Sutton

By LOUIS V. SUTTON

President, Carolina Power & Light Co., and President, Edison Electric Institute

THE nation's electric light and power industry in 1950 demonstrated its ability to provide electricity for both defense and civilian needs, and at the same time registered impressive gains in electric generating capability, power production, sales and customers.

A major gain recorded in 1950 was the installation of 6.7 million kilowatts of new generating capability. The electric companies' expansion program, begun at the close of World War II, continued in high gear; and the companies stepped up the tempo of capacity additions as well as placing large orders for equipment deliveries to maintain the existing high rate of generating capacity installation over three or four years ahead.

Power generation moved up sharply during the year, reaching a new high for the electric industry of 328 billion kilowatt-hours, nearly 12 per cent greater than the previous record output of 1949. The addition of 58 billion kilowatt-hours generated by industrial and railway plants for their own use brought electricity production by all sources in the United States to a total of 386 billion kilowatt-hours for 1950.

Industry Ready for National Emergency

Progress made in 1950 indicates the strength of the electric industry and gives firm backing to the conviction that in a national emergency the industry can match its record of service to the country in World War II, when there was plenty of power for every need, whether military or civilian. The industry's kilowatt-hour generation in 1950 was twice that of 1941; reserve generating capability was about equal to the reserves at the time of Pearl Harbor; and important improvements have been made during and since World War II in operating efficiency, power pooling and interconnection of electric systems.

The business-managed electric companies, with 85 per cent of all electricity sales, have by far the greatest responsibility for electricity supply. Since the end of World War II, the companies have been engaged in a $15 billion expansion program, unequaled in the history of any industry, which is expected to add more than 31 million kilowatts of generating capability by the end of 1953. This expansion is now half completed, and the successful attainment of the projected 1953 goal is contingent on there being no interference with manufacturers' schedules.

Such interference could have serious effect on the power supply situation. Alteration of these schedules could not increase the amount of electric generating capability to be installed in the next two years. It would upset power supply plans carefully made by the utility systems to suit the needs of their areas. Also, it must be emphasized that if equipment intended for the nation's electric systems should be diverted to other purposes, our predictions and expectations would, of course, be without the foundation which careful planning, ordering and scheduling have provided.

Assuming that construction is allowed to proceed as planned, the electric companies will have over 75 million kilowatts of generating capability at the end of 1953, which is more than twice the figure at the beginning of 1941. For the industry as a whole, the 1953 total will be 93$^1/_2$ million kilowatts.

Under the projected expansion, reserve margins of generating capability are expected to show successive increases, reaching 14$^1/_2$ per cent of the year's peak in 1951; 18 per cent in 1952; and 20 per cent in 1953. The calculations of load growth on which these reserve margins are based do not include large individual defense production plans on which no definite information is available at this time. As such large individual requirements appear, there will probably be some drawing upon these reserves and, in addition, special provisions for installation of power facilities will be necessary. It is of course important that the locations of any such heavy defense loads be established with due regard to available power reserves.

Two Million New Customers

How well the electric industry is serving the people of the nation is indicated in the gains in number of customers and in power use. Some two million new customers came on electric lines in 1950, bringing the total to 45 million, and marking the fifth straight year in which more than two million customers have been added, the highest "new customer" rate in industry history. In the homes of America, about 98 per cent of which have service available, electricity use registered its largest annual increase; and average price of electricity to the residential consumer declined to a new low of 2.89 cents per kilowatt-hour.

In attaining a new high of 280 billion kilowatt-hours in 1950, sales of the electric industry increased 12.6 per cent over the previous record set in 1949. Residential

sales were 67 billion kilowatt-hours, 15 per cent over 1949; and commercial sales totaled 51 billion kilowatt-hours, for a 10 per cent gain.

Sales to large power users composing the industrial classification comprised 50 per cent of all sales, and showed the greatest gain, 18 billion kilowatt-hours, or 15 per cent over 1949.

Home Use Scores Record Rise

Residential consumers in the United States, who constitute over 80 per cent of the electric industry's customer total, increased their individual annual average use of electricity by 145 kilowatt-hours, the highest yearly gain yet recorded. Average consumption by the home customer in 1950 was 1825 kilowatt-hours, nearly 50 per cent greater than the average use in 1945.

During this period, the cost of living index jumped over 47 points, but the residential electricity index showed a decline of more than 2 points. In 1945, the cost of living index stood at 128.4, while the residential electricity index was 93.1. The 1950 average for the cost of living was 176.0; for residential electricity, the average was 90.5. Average revenue for residential electricity declined 15 per cent from 1945's 3.41 cents per kilowatt-hour to 2.89 cents in 1950.

Farm Use Shows Impressive Gain

With about 93 per cent of the farms in the United States now either taking electric service or having it readily available nearby, and with the task of extending rural distribution lines approaching practical completion, continuing efforts to develop the most effective applications of electricity to agriculture have acquired primary emphasis. Indicative of the progress which has been made in this important field is the growth in electricity consumption by the farm customer, which, in 1950, reached an annual average of 2350 kilowatt-hours on those farms where irrigation is not a factor. This total includes one of the largest year-to-year gains made in farm use of electricity and is approximately 50 per cent greater than the average of 1571 kilowatt-hours consumed by the farm customer in 1945.

New Highs in Revenues and Net Income

Along with accomplishments in other phases of electrical operation, advances were recorded in revenues, net income and dividends during 1950. Gross revenues of the electric companies increased by some $365 million over 1949, an increase of 9 per cent, and totaled $4475 million for the year. But due to increased expenses, principally taxes, net income in 1950 did not show a commensurate gain, although it did reach $820 million, a new high, which was an increase over 1949 of $55 million, or 7 per cent. This estimate, however, does not include the possible effects of any retroactive excess profits tax legislation that may be enacted. Dividends on common and preferred stocks of the electric companies totaled $620 million for 1950.

During the year, more than two billion dollars was spent by the electric companies on new electric plant and equipment, bringing the total plant investment, including that devoted to gas in the so-called "combination companies," to $21.5 billion, an increase of almost 10 per cent over the 1949 total.

Taxes Total One Billion Dollars

For the first time in electric industry history, taxes of over one billion dollars were paid by the companies, including those with gas departments. For electric operations only, the 1950 tax bill was $937 million, 18 per cent higher than in 1949, and was the leading expense item. While this figure includes the higher tax rates which went into effect during the year, it makes no allowance for any retroactive effect if an excess profits tax should be imposed.

Taxes for 1950 amounted to about 21 per cent of electric company gross revenues, as against 19 per cent in 1949. About $550 million went to the support of the Federal government, while state and local governments received the remaining $387 million.

Participating in the general upward trend, other electric company expenses were also higher. Wages and salaries followed taxes as the second largest expense item in 1950, amounting to $920 million, about $58 million over the figure for 1949, when payrolls were first and taxes were second. The third largest expenditure in 1950 was for fuel, a total of $766 million, $60 million greater than the fuel bill for 1949.

Advances in Industrial Use

In 1950, an all-time high of 139 billion kilowatt-hours of purchased power was used by American industry and commerce. The number of kilowatt-hours used per man-hour in manufacturing rose to more than 6 from the figure of 4 during World War II, an increase of 50 per cent. In effect, this development has added the potential output of 1.5 million production workers to the nation's productive capacity over the peak war years of 1943–1944.

Also impressive is the growth in the annual average of kilowatt-hours used per worker in manufacturing, bringing the 1950 average to 14,000 kw-hr which is 60 per cent greater than that of 1939.

While electricity has been playing an increasingly important rôle in manufacturing processes, it has been taking a consistently smaller place in costs of production. In 1939, purchased power cost was 1.41 per cent of the product value for all manufacturing; but by the end of 1947, the latest year for which comprehensive data on industrial power are available, the percentage had been reduced almost half to about three-quarters of 1 per cent of product value.

Because electric power is basic to the nation's strength, the men and women of the electric industry make up one of the most valuable components in the U. S. working force. They are the most important of the electric industry's resources—through the consistent quality of their performance and the vast amount of experience they have gained in meeting and successfully solving the special problems and situations inherent in operations during periods of stress.

Power plants and transmission systems of the industry are run by competent, loyal, experienced, skilled forces of operators, whose ability to turn out the power has never failed in the hour of need. This is a record of which all of us in the industry are proud—and we shall guard it in all future emergencies with all the determination we possess.

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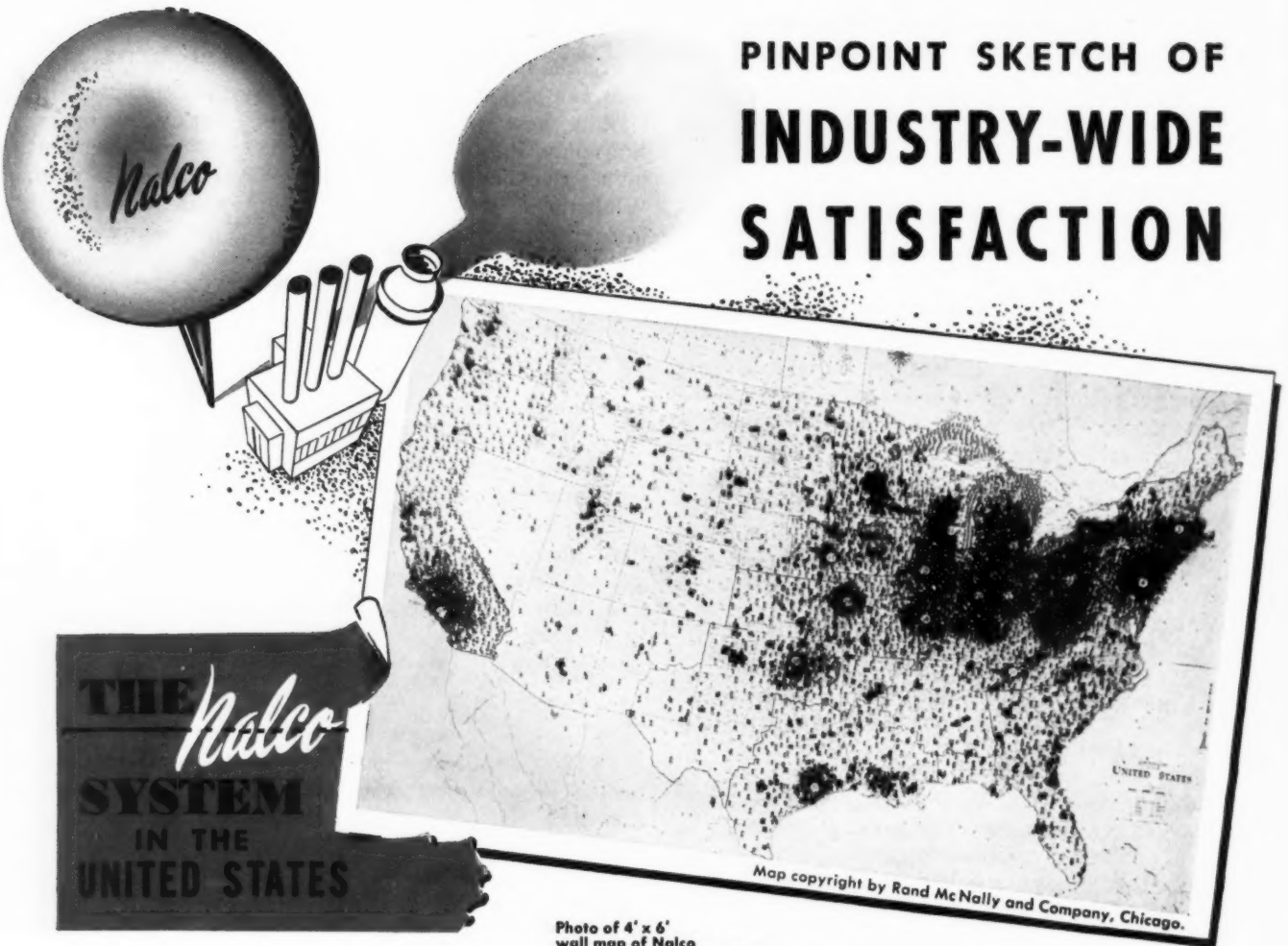

Photo of 4' x 6' wall map of Nalco Industrial Department. Each pin locates a user of The Nalco System. Pins in Great Lakes are Nalco System ships.

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Steam Power Activity and Trends

Orders for steam generating units and turbine-generators reached a new high during 1950. Large capacities and more widespread employment of high steam pressures and high temperatures were noted. A high spot of the year was orders for nine large controlled-circulation steam generating units.

WITH new steam plant equipment orders for electric utilities exceeding all predictions, especially during the second half of the year, 1950 marked a new record in power activity which also included the new plants and extensions that went into service and contributed to a new high yearly output of approximately 328 billion kilowatt-hours.[1] This represents an increase of around 12 per cent over the 1949 output. Of this total, that produced by fuel-burning plants was 71 per cent and water power 29 per cent. In other words, despite some increase in hydro output, by far the major portion of the large increase in demand was carried by steam plants. This is further indicated by the accompanying chart taken from a recent report by the Federal Power Commission. Moreover, judging from the relative steam and hydro capacities building and on order, the preponderance of steam-generated power will continue. During 1950, more than five million kilowatts of steam generating capacity and over a million kilowatts of hydro capacity were added, bringing the total present installed capacity, for privately owned and publicly owned utilities, up to 67 million kilowatts. About the same ratio of five steam to one hydro applies to capacity added and scheduled over the five-year period 1948–1953, at the end of which time over 36 million kilowatts will have been added.

In this connection it may be noted that the TVA, which heretofore has been regarded largely as an outstanding example of hydro power, has lately turned to steam to meet its rapidly increasing normal load and vast additional defense demands for power. Besides its Watts Bar steam plant, which has been operating for several years, TVA has under construction or contract nearly three million kilowatts of steam-electric capacity in four new stations, one of which will be the second largest in the world.

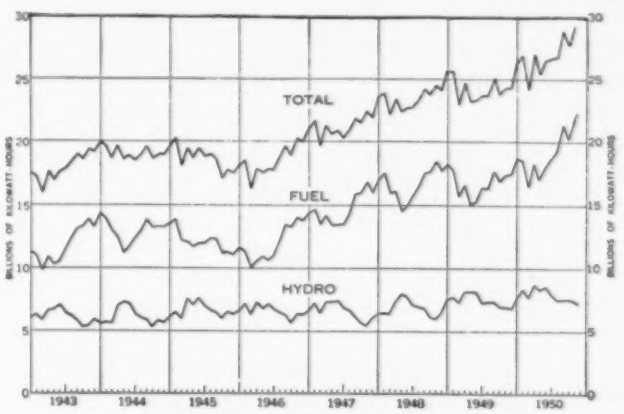
The influence of the new, more efficient plants is reflected in figures recently released by the Federal Power Commission showing that in October, the latest month for which data were available, the average economy of steam-electric central stations was 1.17 lb of coal per net kilowatt-hour, as compared with 1.24 lb for the same month in 1949. Some individual stations and units averaged for the year well under 10,000 Btu per net kwhr.

Steam Generating Units

Orders placed by the electric utilities in this country for steam generating units during the past year represented a total rated output of over seventy million pounds of steam per hour. This is greater than the average capacity shipped per year during the last three years which, according to a recent EEI Survey, amounted to less than 60 million pounds of steam per hour. The rated output of steam generating units for industrial power plants amounted to between 25 and 30 million pounds per hour. In addition, there was a large number of export orders, some identified with ECA and others independently financed. Many of these were for foreign utilities and of large capacity.

Of the utility units ordered, 19 were for outputs of a million or more pounds of steam per hour. Design pressures of 2000 psi and above are specified for 15 units and steam temperatures of 1000–1050 apply to many of the larger units. In fact, based on satisfactory experience with 1050 F steam temperature, plans are being made in at least one case for employment of 1100 F.

The predominance of large units and general acceptance of the single-boiler, single-turbine arrangement is traceable to the high availability of such units, a substantial saving in initial cost and a saving in operating labor. Moreover, the widespread use of reheat among the 1950 units, as a step toward improved station economy, has been favored by the single-boiler, single-turbine combination.



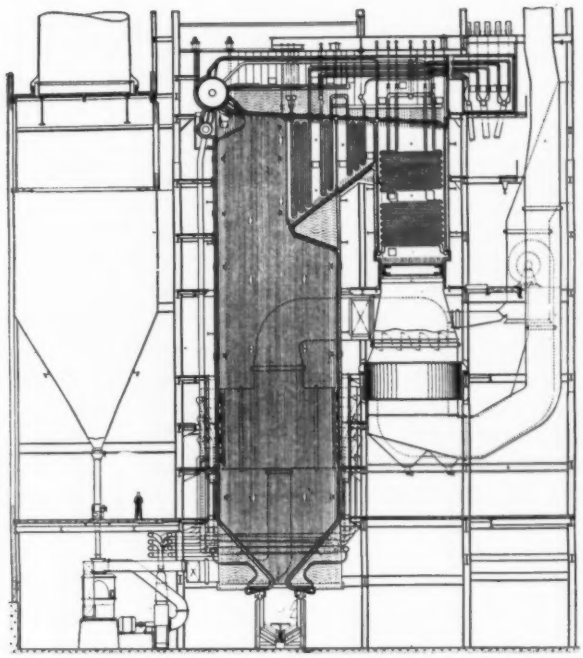
Fuel and hydrogenerated power

Reviewing the designs of recent units and those on order, one notes a trend toward single drums, the absence of baffles, conservative furnace heat releases, arrangement for burning multiple fuels, more semi-outdoor installations, regardless of location, and as previously mentioned, higher steam conditions.

With single steam generating units being designed to serve 150,000 kw and over, there are indications of the desirability of employing a furnace division wall in order to provide the required heat absorption surface without making the furnace dimensions unduly great. Also, if steam temperatures continue to increase further, it may be necessary with reheat to incorporate radiant superheater surface.

Automatically controlled vertically adjustable burners are now becoming standard with tangential corner firing, and remote centralized control for both steam gen-

[1] From estimates based on data supplied by the Edison Electric Institute.



Typical large steam generating unit

erating units and turbine-generators is gaining in acceptance. In this connection, the application of television to afford the central control operator a continuous observation of what goes on in the furnace is an accomplished fact and is expected to have wide application.

Some attempts have been made to eliminate the induced-draft fans and substitute pressure combustion in order to save on their maintenance and fan power; but such an arrangement means a completely sealed furnace which introduces certain design and operating problems. Although one or two such installations have been made, opinion is divided regarding it, and further study based on experience is indicated.

There also appears to be a demand upon the part of operating companies for still higher efficiencies with the large units, to an extent consistent with cold-end temperatures that will avoid corrosion in the air heater.

Finally, perhaps the most outstanding advance of the year, and one that is likely to presage a new era in high-pressure steam generating practice, was the placing of orders for nine large high-pressure, high-temperature controlled circulation units[2] by five well-known utilities. All these employ reheat and range in sizes from 795,000 to over a million pounds of steam per hour with operating pressures ranging up to well over 2000 psi and initial steam temperatures from 1000 to a possible 1100 F. The combined rated output of these nine units will exceed eight million pounds of steam per hour, and supply over a million kilowatts of turbine-generator capacity.

During 1950, utility boilers burned 90 million tons of coal, 77 million bbl of oil and 624 billion cu ft of gas, large amounts of oil and gas being made available by the post-war construction of many long-distance pipe lines. Although coal consumption dropped off considerably in the first half of the year, due to interruptions in supply, the second half of the year saw its use for power generation stepped up beyond that of the previous year and coal stocks in the hands of consumers reaching a new high.

Much of the residual oil burned was of foreign origin and contained appreciable percentages of vanadium and sulfur which were blamed for a number of cases of attack on superheater spacers and hangers. This led to a very comprehensive survey of oil-burning plants, which was reported in a paper before the 1950 A.S.M.E. Annual Meeting. The conclusions reached were that the number of serious cases was not as great as at first indicated; that while vanadium probably is a factor in promoting attack, sodium sulfate is equally responsible; and if superheater tube temperatures are kept under 1100 F, little plugging and hot-end corrosion need be expected, providing good combustion conditions are maintained. Considerable cold-end corrosion was reported.

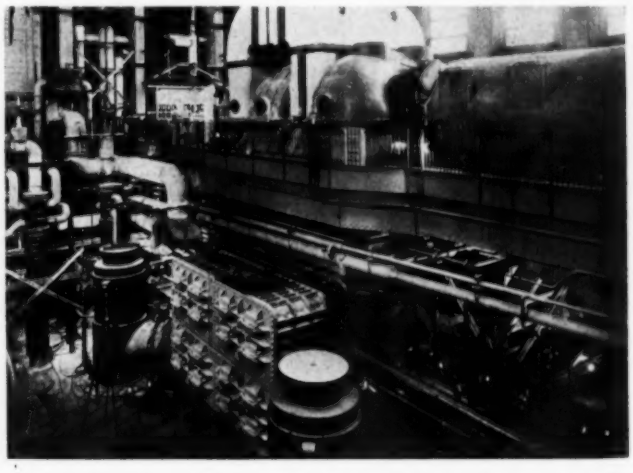
Turbine-Generators

During the year there was a marked increase in the number of turbine-generators installed and ordered for capabilities of 100,000 kw and over, one turbine manufacturer reporting that it has built or is building 35 units of this size or larger, including nine of 125,000 kw. One unit of 165,000 kw rating and at least two of 150,000 kw capability went into service and others of comparable size are now on order.

Another turbine manufacturer reports that 43 per cent of the capacity ordered during 1950 was for steam pressures in excess of 1250 psi at the throttle, including 12 per cent for pressures over 1450 psi. One unit at 2000 psi and others at 1800 psi went into service and still higher pressure is involved for units in a plant extension soon to be started.

Although 950 F represents the most widely used throttle temperature for new large turbines, more than 25 per cent of the units recently installed or on order call for 950 to 1050 F. As previously mentioned, one new installation calls for an ultimate throttle temperature of 1100 F.

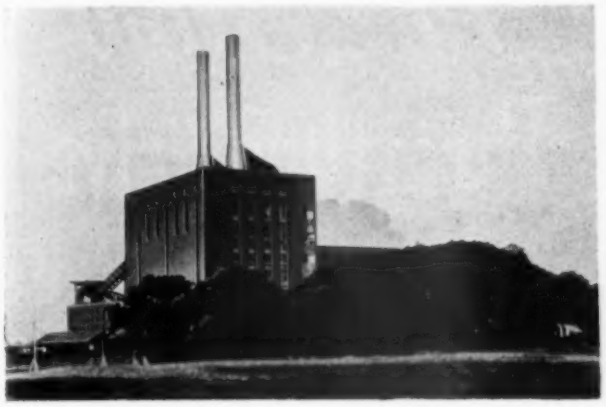
Although single casing machines are built in sizes up to 90,000 kw and 1250 psi, 1000 F, double shells are favored for the higher temperatures, inasmuch as thinner walls can be employed and stresses due to thermal shocks reduced. The steam piping is now welded to the outer casing.



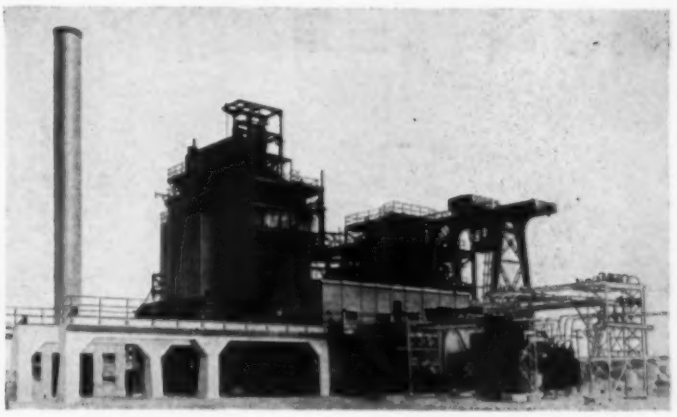
A 165,000-kw turbine-generator placed in service during 1950

[2] Commonly referred to in the field as forced circulation.

Some Generating Stations That Went Into Service in 1950



Dunkirk Station of Niagara Mohawk Power Corporation



Jim Hill Station of Arkansas-Missouri Power Co.

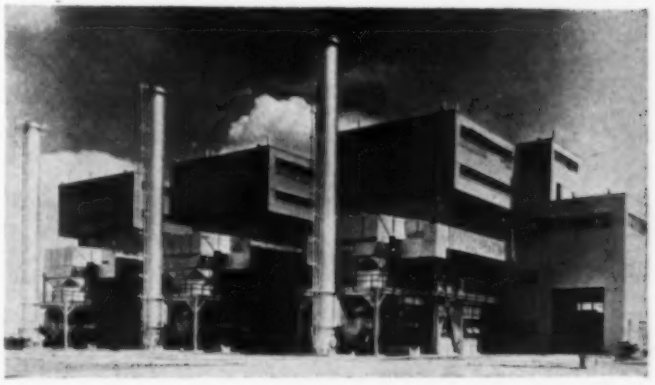
Resuperheat accounts for at least a quarter of the large units now being built, and among the orders of recent months it predominates. The reheat pressures range from 25 to 28 per cent of initial throttle pressure and in an increasing number of cases reheat is brought up to the initial temperature, except that where the latter is 1050 F it is usual to specify a reheat temperature of 1000 F.

The A.S.M.E.-A.I.E.E. Preferred Standards for steam turbine-generators have lately been extended to cover reheat machines up to 90,000 kw, although reheat is being applied to other than standard machines of 125,000 kw nameplate rating.

The largest capacity unit put in service during 1950, namely 165,000 kw, is a tandem-compound machine running at 1800 rpm. Cross-compound units of 3600/1800 rpm are being built up to 150,000 kw and tandem-compound, triple-exhaust 3600-rpm machines up to 125,000 kw.

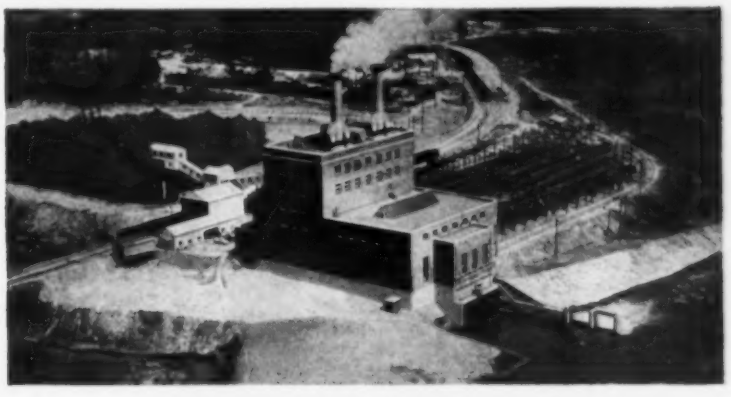
The practice of one turbine builder is to employ carbon steel for casings subject to steam temperatures up to 825 F, whereas for higher temperatures up to 1000 F, low-alloy ferritic steels, such as molybdenum and molybdenum-vanadium alloys, are used. For 1050 F, either a chromium-molybdenum-vanadium alloy or 18–8 austenitic alloy is employed. Another builder favors the addition of 0.5 per cent chromium for temperatures from 825 to 900 F, 2.25 per cent chromium with 1 per cent molybdenum for 1000 F, and austenitic 18–8, columbium-stabilized steel for temperature in excess of 1000 F.

Plant Yates of Georgia Power Co.



Hutchinson Station of Kansas Power and Light Co.

Ridgeland Station of Commonwealth Edison Co., Chicago



Dan River Station of Duke Power Co.

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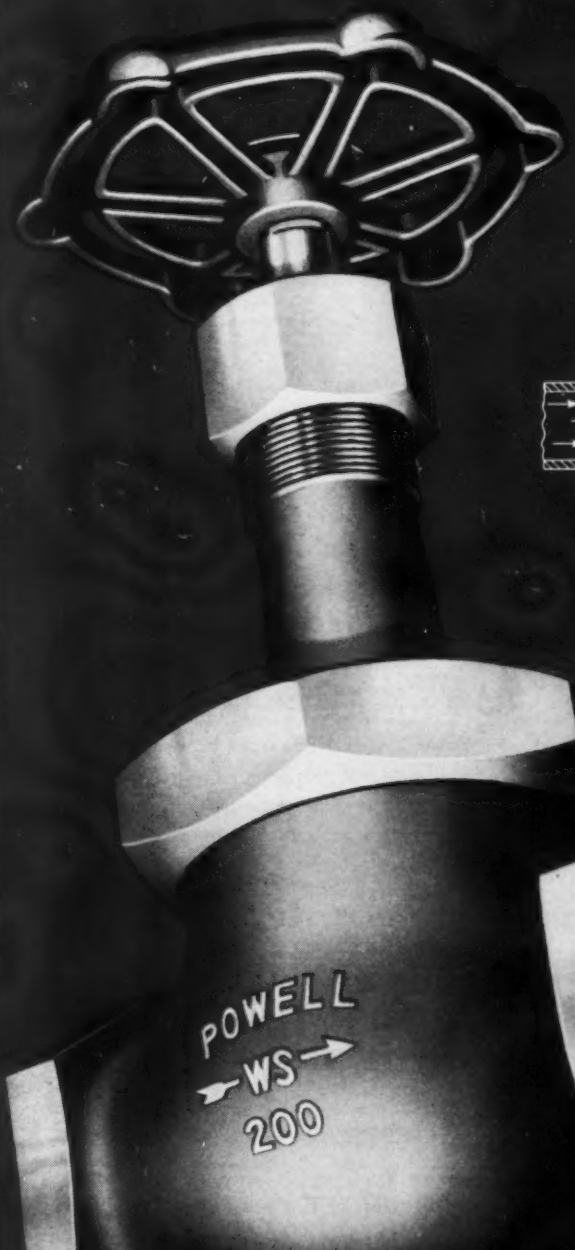

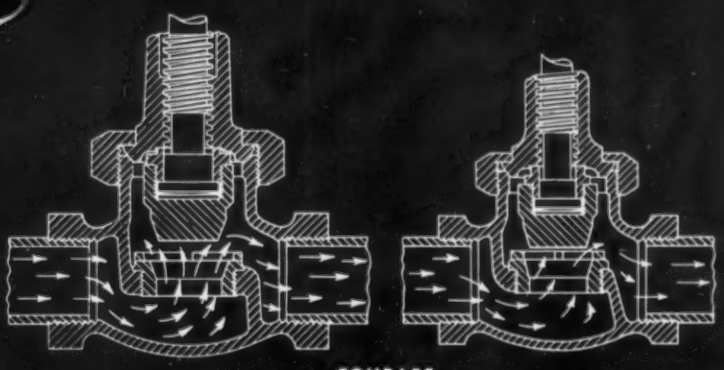

COMPARE
the flow characteristics of the new Powell "W.S." Valve (left) and the ordinary globe valve (right). Note the extra large opening through the seat (nominal pipe size) and the greatly increased lift of disc, when wide open.

This is actually a dual service valve in that it can be throttled to any desired degree, yet, when wide open, permits FULL FLOW through the body. Thus turbulence and pressure drop are reduced to a minimum—a triumph in engineering that exemplifies Powell's continual leadership in the field of industrial valve design.

Powell "W. S."
Bronze Globe Valve
Fig. 2608

Write for folder giving full description of the many advanced engineering features of this valve.

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Methods of Handling Coal at Today's Power Plants*

This paper surveys current coal-handling practice for industrial power plants and in large central stations. Emphasis is directed to several methods of unloading, conveying and elevating, and storing and reclaiming coal. Advantages of the various methods are analyzed in terms of trends in the coal supply and utility industries.

By FRANK W. LOVETT

Link-Belt Co.

THE increased importance of coal-handling equipment with relation to overall power plant design is clearly illustrated in recently completed stations. No longer do engineers consider this problem as secondary, for through the years they have learned that maximum efficiency and minimum costs are achieved only by planning the coal-handling system in their earliest studies. In fact, even the site for a large central station cannot be selected with assurance until the logistics of handling coal are determined.

None of the problems of today are new, but their importance has been intensified by economic and social trends and by progress in overall power plant design. The following problems deserve examination:

1. Because of greater generating capacity of individual stations, systems must be provided for unloading and handling coal at greatly increased hourly rates. These stations require more dependable performance to protect the greater investment and to insure continuous electrical output.

2. Poorer coals currently available present many problems to the conveyor designer. Wet fines, sometimes with considerable clay, are more difficult to handle in hoppers, chutes and bunkers. Under some conditions the coal may be high in sulfur, creating a corrosion problem. Difficulties with frozen coal increase with the handling rate.

3. The coal supply itself has developed into a serious problem the past few years. Potential mine strikes and transportation delays dictate increasingly large reserve storage at the powerhouse site, a problem which increases with the size of the station. However, ample storage space does permit the purchase of coal at favorable prices for future use.

4. Higher labor costs and the difficulty of obtaining men to work at the unloading station when cleaner, less hazardous jobs are available must be considered. Capacities that will make possible one-shift operation are indicated, along with better and safer working conditions.

5. Better housekeeping of modern plants requires

* Abstract of a paper presented before the Materials Handling Division at the 1950 A.S.M.E. Annual Meeting.

effective means of controlling dust, especially at unloading stations and subsequent transfer points.

Coal-handling systems suitable for solving the problems of today's central stations will vary in cost between $3 and $5 per kilowatt of installed capacity. The cost will depend upon the type, capacity and scope of operation of equipment used.

Unloading

One of the biggest problems is how to get the coal out of hopper-bottom cars. It arises mainly from the extensive use of wet screenings, "bug dust" and low-grade coals containing a large percentage of clay.

Where coal is received by rail, the unloading of hopper-bottom cars has always been considered a costly, dirty, tedious and, in a good many cases, a dangerous job. One of the most important features in the design of a receiving hopper is the slope of the sides. Recent experience has shown that a minimum slope of 50 deg with the horizontal should be used and that this slope should be increased to 60 deg or higher when handling wet screenings or "bug dust."

The size of hoppers depends a great deal on the capacity of the coal-handling system and whether hand cleanup is to be avoided. In smaller plants where a few cars are handled, a hopper as wide as the track and just long enough to take care of the angle of repose of the coal from one door of the car is sufficient. This size hopper requires considerable cleanup.

Usually track hoppers for single cars range from 12 ft by 12 ft in plan to 14 ft by 28 ft. The latter size is used when it is desirable to unload a car completely without moving it. The capacity of the hopper in this case should be at least 70 to 80 tons to hold a complete car of coal. This is advantageous where car shakers or other mechanical unloading devices are used, as it will permit the removal of the empty car and the spotting of a loaded car while coal from the previous car is being fed to the system.

In plants up to 300 tons per hour capacity, hoppers of sufficient length to accommodate two cars are often used. Here again the capacity of the hopper or hoppers should be sufficient to hold the contents of both cars.

Car Shakers

With the present design of hopper-bottom cars it often requires from three-quarters to one hour for three men to unload completely a car of "bug dust" that is not frozen. With a modern car shaker this car can be unloaded in 10 to 15 minutes. For this reason car shakers are now used extensively to assist in unloading wet screenings or "bug dust" and for increasing unloading capacities. A fair average capacity for a car shaker under most operating conditions is 6 to 8 cars per hour, or about 300 to 350 tons per hour.

The car shaker is normally suspended from a hoist located at about the center of the car and lowered to the car after it is spotted over a track hopper. Rotation of the vibrator shaft at its normal speed causes the vibrator end of the shaker to rise and fall, imparting heavy hammer-like blows to the car. The energy of these impacts on the vertical car sides is transmitted directly to the sloping portions of the hopper car bottom, producing the action needed for loosening and unloading the coal.

Rotary Car Dumper

The use of a rotary railroad car dumper in plants receiving coal by rail is continually increasing, particularly for plants handling 300 tons or more per hour. This equipment has the ability to unload any type or kind of coal in the largest or smallest type of open-top gondola cars and to empty the car by the simple expedient of turning it upside down.

A single dumper designed for power plant use will easily handle from 20 to 30 standard railroad cars per hour, and some have been designed for 40 or more cars per hour. As these dumpers are rugged in design they are seldom installed in duplicate. Because of their high capacity and dependability there is no necessity of using a number of large track hoppers with auxiliary equipment. Dumpers make it possible to unload economically and provide safe and desirable jobs for the operating crew.

Unloading hoppers, whether located directly under hopper-bottom cars or under a car dumper, are usually housed to prevent accumulation of coal and ice, particularly in colder climates. However, there are some cases in which coal is unloaded without the protection of an enclosing house, even when a car dumper is used.

While the use of car shakers or dumpers will facilitate the unloading of frozen coal, it is good practice to provide thawing pits in localities having long freezing seasons. Coal in hopper-bottom cars that has been in transit several days in sub-zero weather may freeze solidly in the bottom of the car hoppers. Sufficient heat should be provided under the car to permit opening of the gates and allow the coal in the hopper bottoms to be thawed out or broken up before a shaker is effective.

Feeding Coal to System

The apron-type feeder and the reciprocating or sliding-plate feeder are still extensively used. Belt feeders, however, are increasing in popularity primarily because they are simple in design, very readily made dust-tight and are easy to maintain and repair.

Properly designed loading chutes and skirt sides, with close spacing of impact idlers, will provide a long-lasting dependable belt feeder suitable for large-capacity installations handling wet and sticky coal.

Large unloading hoppers and multiple feeders have increased the use of variable speeds for feeders. Speed regulation is accomplished by means of multi-speed motors or by mechanical or electrical variable speed transmissions. Feeders should be designed to operate at slow speeds and discharge uniformly to the conveying medium. Feeders of apron and belt conveyor types lend themselves more readily to these functions than does a reciprocating type feeder when used for handling wet and sticky coal.

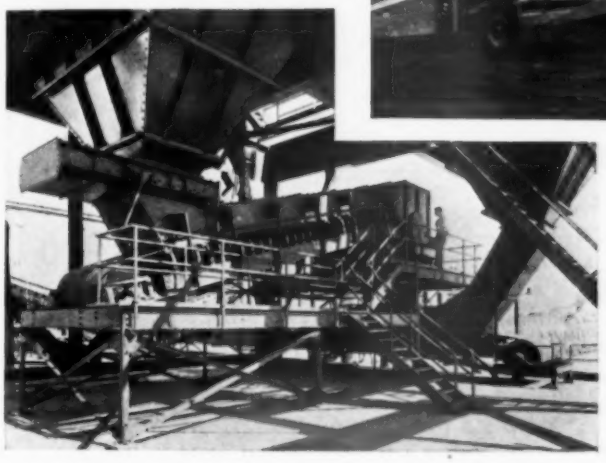
Conveying and Elevating

For small and medium size plants, the bucket elevator is still the most economical means of elevating coal. The type and size depends on the capacity and kind of coal to be handled, with emphasis on the use of slower-moving units and extensive use of alloy steels for wearing parts.

Screw conveyors and the bulk-flow type of conveyors

Methods of Handling Coal

Bulldozer and carryall at stacking-out conveyor

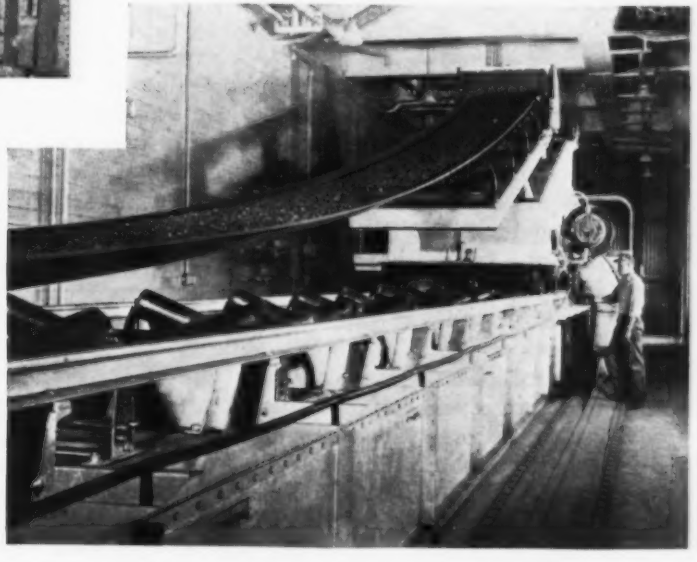


Totally enclosed belt feeders at transfer point

Rotary car dumper in operation

Traveling tripper and stacker

Typical apron feeder installation



Tripper on distributing belt over bunkers

are quite adaptable to small plants handling only several cars of coal per week. They are low in first cost, clean because they can readily be made totally enclosed, and take up very little space.

Screw conveyors are used as a coal-distributing medium on small installations. Flight or belt conveyors are the usual distributing medium above coal bunkers at plants of medium size.

The overlapping pivoted bucket carrier, which had long been recognized as an ideal type of combination elevating and conveying equipment for serving medium size plants, is regaining its long-time popularity. Serving as both a conveyor and elevator and carrying the coal in any direction within a vertical plane, it is one of the most practical and economical units used for handling coal.

Belt conveyors have long been known to be an economical means for elevating and conveying bulk materials. They are used almost exclusively in coal-handling systems of 150 tons per hour or greater capacity, and some of the recent stations are using single-length belts handling from 1000 to 2400 tons per hour. The modern belts, using cord construction of nylon, rayon fabrics or steel wire, have permitted increasing the length of single belts to as much as 11,000-ft centers. For this reason power plants may be located at considerable distances from coal-receiving points or reserve storage piles.

When handling run-of-mine or frozen coal, it is considered good practice to make the angle of inclined belts not more than 16 deg and preferably less. The angle may be safely increased to 18 deg when handling crushed coal of $1^1/_2$ in. size and under. On long inclined belts to the bunkers it is also considered good practice to break the conveyor belt at the point where conveyor enters the building and provide a separate drive at this point. The distributing belt over the bunkers is then a separate horizontal belt that may be increased in length as plant facilities expand.

Belt conveyors are usually supported on bridges or galleries completely covered or left open with a protective covering over the belt only. In some recent stations the main belt conveyor from unloading point to breaker or crusher building and to the power plant are completely covered, but the stacking-out and reclaiming conveyors are open with only the belt covered.

Crushing

It is customary to install some means of sizing run-of-mine or frozen coal in practically all power plant coal-handling systems. Either crushers or breakers are used. Breakers are usually employed where large capacities are handled to provide sized coal of $1^1/_2$ in. and under, the crushed coal traveling directly to stokers, pulverizers or conditioners. In addition to providing primary crushing, the breaker also removes foreign materials.

Storage

Large or small, each power plant must provide excess storage to assure continuity of operation. The amount of coal carried in storage depends not only on the actual coal consumption of the plant but on many other factors, and a 60 to 90 day supply is usually considered adequate. Some of the larger central stations burn from 4000 to 6000 tons a day and require a reserve storage of a half million tons or more. Other large stations which receive their coal by water must provide as much as six months' storage for winter operation because of weather limitations on the navigation season. It has been found that the ability to store and reclaim large quantities of coal economically at almost any time of the year has enabled some stations to buy large quantities of coal at favorable market conditions. Previously stored coal may be burned when coal costs are unfavorable, resulting in the saving of hundreds of thousands of dollars at many large plants.

All of this has led to the need for developing large and more flexible systems for the stocking out and reclaiming of coal. Regardless of size, ground storage is used at most plants. Bulldozers and carryalls have shown that they can be operated over rough terrain for prolonged periods without excessive operating costs or maintenance, and they are now being used quite extensively for storing and reclaiming coal. They convey and pack the coal to 60 or 70 lb per cu ft. This compacting not only permits greater storage capacity over a given area as compared to loosely piled coal but also limits oxidation and reduces the hazard of spontaneous combustion.

The handling capacity of both bulldozers and carryalls is definitely a function of the working radius. Generally it is considered that a bulldozer may economically be used for a radius up to 200 ft and that a carryall is more economical for large radii. Usually both bulldozers and carryalls operate from an initial storage pile. Bulldozers push the coal direct to the compacted piles or spread it out so the carryalls can pick it up. The initial pile is usually placed some distance away from the main buildings in order to avoid the dust nuisance. A large initial pile allows more freedom in the operation of the bulldozer and carryall equipment, with less chance of bumping into the conveyor supports or building structure.

Stocking out belts are used at plants having high-capacity unloading facilities and at plants which receive their coal from self-unloading boats at rates of up to 2000 tons per hour. These belts discharge to traveling stackers which form an initial pile of any desired length, from which the coal is bulldozed to the compacted pile at a convenient time. Another way of loading coal into carryalls is by means of overhead storage bins holding up to 150 or 250 tons, having discharge gates located about 12 ft above grade. These gates are readily operated by the carryall operator, and the carryall can be loaded in about a minute.

Reclaiming

When reclaiming by means of bulldozers and carryalls, one or more reclaim hoppers are usually provided at grade level to receive coal for delivery to the crushers or breakers. Reclaim hoppers are generally made a minimum of 16 ft square in plan to accommodate the largest bulldozers or carryalls and require the least amount of cleanup. In some plants coal is reclaimed through the track hopper, but it is considered good practice to provide a separate reclaim hopper as it provides a secondary means of getting coal to the plant in an emergency. Where long yard belts with traveling stackers are used for stocking out, these same belts can be used for reclaiming by using movable clam shell bucket cranes and loading hoppers.

By-Products Used as Fuels

By

C. G. R. HUMPHREYS

Research Dept., Combustion Engineering-Superheater, Inc.

THE source of all of the world's supply of energy is solar radiation. The only means of entrapping and storing this energy is the chlorophyll reaction, or the manufacture of carbon-hydrogen compounds by growing plants.

The primary worldly source of fuels is therefore vegetation. Such major fuels as oil, gas, coal and peat are fossil forms of plant life.

Any material containing carbon, hydrogen and sulfur has fuel value. In addition to the major fuels listed above, there are many lesser known fuels in common use for the production of process steam and power. These are the waste or by-product materials of manufacturing processes. In utilizing these materials an additional purpose is served. If they are not burned, their disposal often poses a problem of expense chargeable to the manufacturing process, thereby increasing the total cost of the product.

The lumber industry produces large quantities of waste wood as sawdust, shavings, bark and culls that in the not far distant past were wastefully burned in incinerators. In present-day practice a larger percentage of the log is utilized, and many of the heretofore waste materials are now processed into useful products. This has increased the power requirements of the lumber industry, and the by-products now used as fuel barely supply sufficient power to meet these needs. More attention is now being given to using the remaining waste fuels at higher efficiency.

The pulp and paper industry utilizes a much greater percentage of the tree than does the lumber industry. The principal combustible by-product is "black liquor," the spent solvent containing the lignin content of the wood. While this is burned as a fuel to produce steam, the principal purpose is the recovery of the chemicals it contains. If black liquor were not utilized as fuel, its disposal, because of more stringent regulations regarding stream pollution, would present an almost impossible problem.

The spent sugar cane or "bagasse" from which the juice has been extracted forms an important fuel in the sugar industry. This fuel when shredded may be burned on refractory hearths or, more efficiently, on automatically controlled spreader-type stokers. Bagasse will usually supply all of the fuel requirements of raw sugar mills.

Another fuel very similar to bagasse is guayule fiber from which rubber latex has been extracted.

Spent tan bark has but little fuel value because of its high moisture content. The principal consideration in burning this material is its disposal rather than its utilization. In fact, auxiliary fuels are often required to effect its combustion.

Other industrial by-products or wastes that have been used as fuel are rice hulls, oat hulls, coffee bean hulls, spent coffee grounds, cottonseed hulls, cottonseed cake, flax straw, linseed cake, furfural waste, lampblack, coconut hulls and straw. While not properly classified as a waste or by-product, cob and shell corn and other grains have been used as emergency fuels, particularly in South America where fuel shortages have been known to coincide with grain surplus.

TABLE—HEAT VALUE OF BY-PRODUCT FUELS

	Moisture, Per Cent	Ash,* Per Cent	Heat Value,* Btu per Lb
Woods			
White pine	40	0.1	8,900
Yellow pine	35	1.25	9,600
Red wood	50	0.25	9,000
Fir	35	1.0	8,500
Hemlock	50–60	2.0–2.05	8,300
Black Liquor			
Soda	20–25	45	6,200
Sulfate	35	40–45	6,500
Sulfite (Ca)	45	10	8,000
Bagasse	40–60	3.0	8,000
Guayule fiber	–	12.0	9,000
Bark (spruce)	60	5	9,000
Bark (pine)	40–50	5–10	9,500
Rice hulls	3–5	25	6,000
Tung oil hulls	6.0	3–4	8,000
Cottonseed cake	8–10	8	9,500
Linseed cake	10	12–14	8,750
Flax straw	10	2.0	8,250
Furfural waste	20–25	3–4	8,200
Lampblack	3.0	0.5	14,800
Wheat straw	10	4	8,500
Spent coffee	65	1.5	10,000
Corn on cob	15–18	1–1.5	8,200
Shelled corn	10–12	1–1.5	9,300

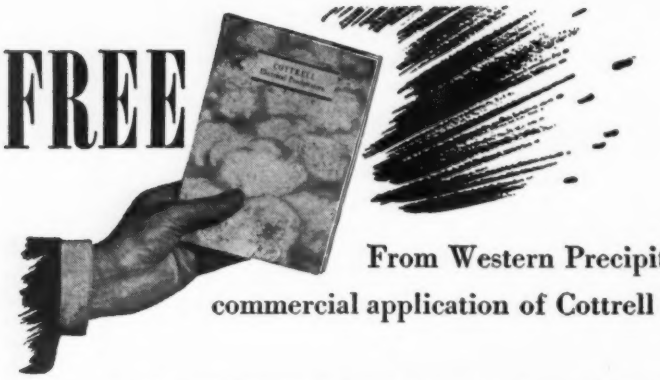
* Dry basis.

The moisture content on an "as received" basis, and the ash and heat value on a dry basis for typical by-product fuels, are given in the above table.

The combustible content of practically all of these fuels is cellulose, a carbohydrate. In such compounds the hydrogen and oxygen are present in the same proportions as water, and the heat value is almost entirely due to the carbon content. With few exceptions the ash content is very low, the principal impurity being moisture.

The heat content of these waste fuels may be approximated on the basis of 8000 Btu per lb on a dry and ash-free basis. This is slightly higher than the heat value of pure cellulose and makes allowance for resinous material that may be present. For resinous woods and fuels containing oil residues, 9000 Btu per lb is a reasonable figure. The "as received" heat value may be calculated from the moisture and ash contents.

FREE



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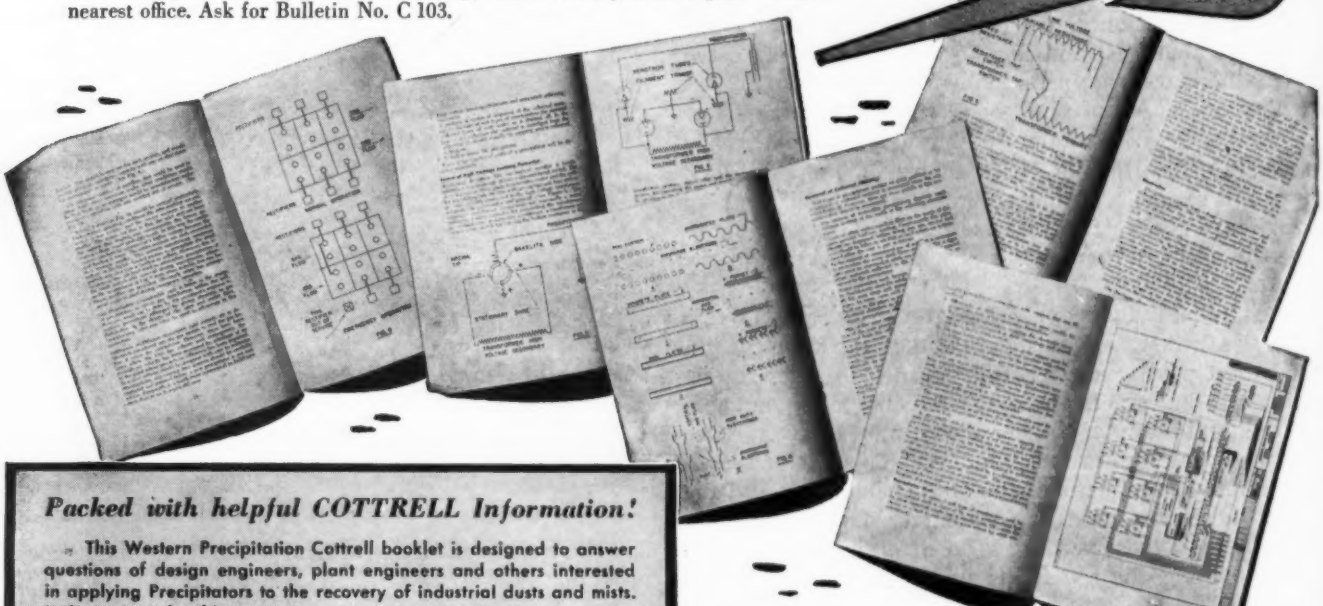

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Determination of Moisture in Coal*

By E. GORDON BARBER

British National Coal Board

ALL coals in their natural air-dried condition, while outwardly appearing dry and in the fine state dusty, contain a certain amount of moisture. This moisture is adsorbed on the outer surfaces and in the inner pore structure of the coal, mainly the latter.

The amount of moisture so retained by any particular coal is chiefly dependent on the relative humidity and temperature of the atmosphere to which the coal is exposed. The higher the relative humidity the greater the amount of moisture adsorbed. If the temperature or relative humidity changes, the coal loses or gains moisture. The changes are greater with some coals than others. A careful study of the effects of temperature and relative humidity has revealed a hysteresis effect, and the amount of moisture retained is not quite the same when starting from a completely saturated sample and decreasing the humidity as when starting from a dry sample and increasing the humidity.

The moisture which is adsorbed on the pore surfaces is frequently referred to as the "inherent" or "air-dried" moisture. The amount of this moisture in British coals may be as low as 0.5 per cent and as high as 15 per cent, depending on the rank of the coal. Broadly speaking, the lower the rank of the coal, the higher the inherent moisture content.

Commercial deliveries of coal in addition to the moisture adsorbed on the pore surfaces may also, depending on their method of preparation, their size and the weather, contain entrained water or "free moisture." Large-sized grades of coal quickly lose by evaporation and drainage any free moisture they may have picked up during washing or in wet weather. Washed fines retain quite substantial quantities of free moisture, even when they are allowed to drain.

In addition to the water entrained and adsorbed in the pores, most coals contain a small amount of water as a part of the clay materials commonly found in coals. This water can be regarded as chemically combined and is not completely released unless the coal is ignited.

Determining Inherent Moisture

As noted previously, the inherent moisture content of a coal will depend on the temperature and humidity of the atmosphere to which it is exposed. Ideally, therefore, the procedure of air drying at a constant temperature and constant relative humidity should be standardized, and the samples on which the determinations are to be carried out should be weighed in a balance room controlled at the same temperature and relative humidity as that at which the air drying has been done. However, common practice is to air dry the coals until they are in equilibrium with the laboratory atmosphere.

A great variety of methods for determining the moisture content have been put forward from time to time. In the main the various methods fall into two broad classes: (1) indirect methods which depend on measuring the loss of weight when the moisture is eliminated; and (2) direct methods, in which the moisture is liberated and collected and measured separately.

In the indirect methods the moisture is determined by measuring the loss of weight when the coal is dried. The drying can be carried out at atmospheric temperature by exposing the coal for a long period to a desiccating agent at atmospheric pressure or in a vacuum. This method is slow and is not used in Great Britain. It is quicker to dry the coal at a temperature slightly above the boiling point of water.

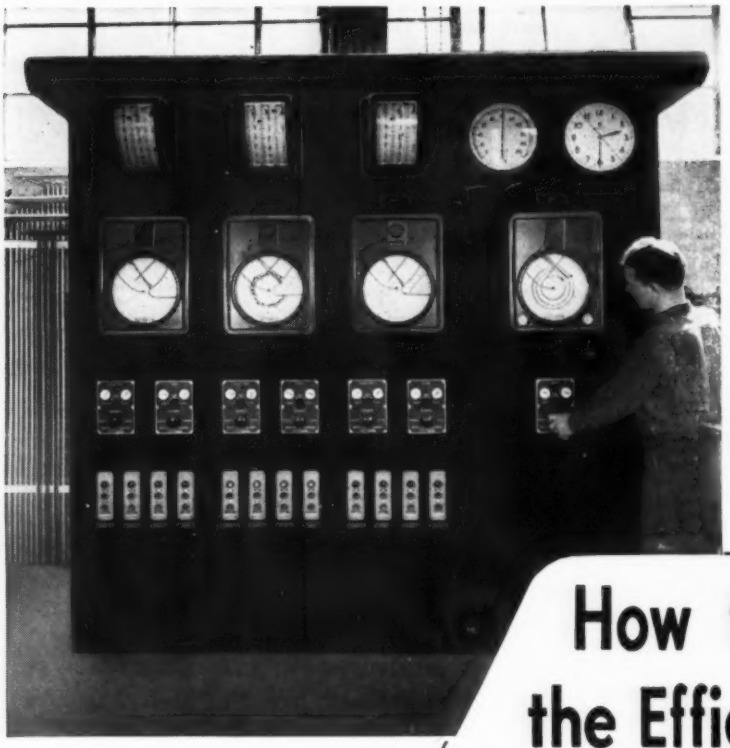
With few exceptions most coals are readily oxidizable, and increasingly as the temperature is raised. Therefore, if the moisture is eliminated by heating at, say, 220 F in the presence of oxygen, there will be a loss of weight due to the removal of moisture and a slight gain in weight due to the oxidation of the coal. The gain in weight due to oxidation may be appreciable with some coals, especially those of low rank. Consequently, when using an indirect method for determining the moisture content it is essential to take precautions to avoid oxidation. There are two ways of doing this, namely, to carry out the determination either in a vacuum or in an inert atmosphere. Nitrogen is used for the latter, but it has been found necessary to remove the last traces of oxygen from commercial nitrogen if reliable results are to be obtained. When the determination is carried out in an atmosphere of nitrogen it is necessary to select an oven with a minimum free space.

Using direct methods the water is eliminated and is either collected in an absorption train and weighed, or is condensed and the volume of the water measured. Methods involving the collection and weighing of the water have been proposed many times in the last 30 years, but none of the methods has come into common use. This is because of the complicated apparatus involved and because of the impossibility of examining a number of samples simultaneously.

Direct methods involving the evaporation and measurement of the volume of the water condensed have been used extensively. A weighed amount of coal is put into a flask and refluxed with a liquid which does not mix with water. The Dean and Stark method, commonly applied to the determination of moisture in petroleum and tar products, has been used for coal in many laboratories. A liquid with a boiling point higher than that of water is required, and toluene or xylene is commonly used. Refluxing is continued until no further water is condensed. There are certain practical difficulties in getting good results, and without an elaborate setup batch determinations are impossible.

The same underlying principles obtain in the determination of the total moisture content as apply to the measurement of inherent moisture content, and the methods fall into two main classes, namely, (1) indirect methods and (2) direct methods.

* Excerpts from a paper presented before the Institute of Fuel in London on December 5, 1950 and appearing in the November 1950 issue of its *Journal*.



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1950 Experiences at Port Washington Station*

INITIAL starting of the last 80,000-kw. unit (No. 5) in this single-boiler, single-turbine reheat plant on December 15, 1950, three months ahead of schedule, is perhaps the station's most significant event of the year. Accelerated system load growth is measured approximately by the decreasing spacing of installation dates of the five units, as follows: 1935, 1943, 1948, 1949, 1950.

No starting troubles were experienced with Boiler No. 5, and though the turbine unit was not assembled at the factory, it was essentially free of trouble. Air leakage through the atmospheric relief valve, causing impaired vacuum and high exhaust temperature, limited turbine speed to 1600 rpm on two short trials, followed closely by another at normal speed. Initial rate of 10,000 Btu per net kwhr. "Boiling-out," high blowdown, low pressure, and low loading until oil and silica contamination are adequately low, increase initial heat rates.

Table 1

OUTPUT AND ECONOMY DATA

Unit No.	Period (Incl.)	Net Output 10^6 Kw-hr.	Btu/Net Kw-hr.
1	1950	475.72	11,024
	1935*-50	6,720.98	10,862
2	1950	513.71	10,651
	1943*-50	3,670.18	10,609
3	1950	569.54	10,057
	1948*-50	1,249.38	10,074
4	1950	604.01	10,027
	1949*-50	788.12	10,007
5	1950*	7.29	11,818
Plant	1950	2,162.4	10,407

*Nov. 22, Oct. 27, Oct. 5, Aug. 25, and Dec. 15 startings, respectively

consequential inlet-valve-stem packing leakage was the only turbine trouble experienced, and the boiler was equally trouble free.

On the fourth starting, five days after the initial turning, the unit was synchronized and run. It was unloaded two days later, for two hours, for its official starting, after which it has remained in service.

Turbine No. 5 throttle pressure is 70 psi over No. 4 (1450 vs. 1380 psig), and its superheat and reheat temperatures are 50 deg F higher (950 vs. 900 F). Two per cent less turbine heat rate is expected. Lower flue gas temperature is expected to improve boiler No. 5 efficiency by two per cent. Heat rate during trials and the first 11 days' operation, to December 26, 1950, was 11,818 Btu per net kwhr. Unit No. 4's first 30 days' rate was 10,220, or about two per cent above its average

Previous Units

Turbine No. 4, started August 1949, is scheduled to be opened for inspection during the two weeks of March 31 to April 15, 1951, after running almost two years. Turbine No. 3, the first of a new design, was opened June 30 to July 16, 1950, inclusive, after similarly operating for its first two years since starting without opening. Its reheat diaphragm clearances were changed from axial to radial, because of diaphragm deflection. That its heat rate continued about the same is indicative of favorable retention of its relatively high efficiency: 10,022, 10,151, 10,079, 10,019 Btu per net kwhr.

Because turbines 1 and 2 each operated four years between inspections, acceptably, present plans contemplate five-year intervals between internal inspections, resulting in opening one of the five turbines each year.

Reliability Data, 1950

Reliability improvement, a trend of several years, continued in 1950. Units 1 to 4 operated 95.1 per cent of the year. All outages totaled 4.9 per cent. Forced outages of the four units were particularly low, being 0.5 per cent of the elapsed year. Boiler-unit forced outage totaled 0.2 per cent, and turbine forced outages 0.3 per cent. "Delayed forced outages" of Table 3 are counted as forced outages, though they are not as serious.

Fig. 2 shows the generally downward trend of total and forced outages for the past several years. As forced outages are made to approach zero, major investment gains and improved service are realized. One per cent less outage time of modern

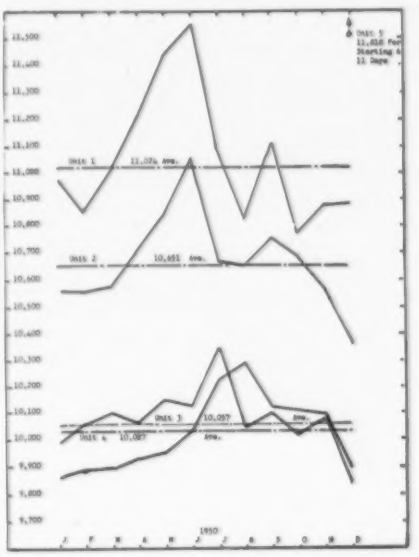

Fig. 1—Monthly Heat Rates, and 1950 Averages

units usually saves as much coal for a typical system as one per cent lower heat rate.

Centralized Controls

The impending serious labor shortage has prompted Unit 5 to be arranged for

Table 2

USE, OUTPUT AVAILABILITY AND FORCED OUTAGE FACTORS

Unit	Period		USE Serv. Hr. / Period Hr.	HOURLY-OUTPUT Av.Hrly.Output / Rated	ANNUAL-OUTPUT Annual Output / Rated	DEMAND Demand Hr. / Period	DEMAND-AVAIL. Service Hr. / Demand Hr.	AVAILABILITY 100-Repair Hr. / Period Hr.	FORCED OUTAGE TIME Forced Outage Hr. / Period Hr.
1	1950	Blr.	94.0	70.5	66.3	99.6	94.4	94.4	0.8
		Turb.	94.0	76.6	72.0	99.2	94.8	94.8	0.4
		Unit	94.0	76.6	72.0	100	94.0	94.0	1.3
	1936-50	Blr.	90.3	67.6	61.3	93.9	96.3	96.6	0.7
	(15 Yr.)	Turb.	90.3	74.2	67.2	97.4	92.8	93.2	1.9
		Unit	90.3	74.2	67.2	99.3	91.0	91.0	2.6
2	1950	Blr.	96.8	73.4	71.0	100	96.8	96.8	0
		Turb.	96.8	79.9	77.3	100	96.8	96.8	0
		Unit	96.8	79.9	77.3	100	96.8	96.8	0
	1943-50	Blr.	93.6	76.0	71.2	96.5	97.0	96.0	0.1
	(7.2 Yr.)	Turb.	93.8	82.0	77.0	98.4	95.3	94.4	0.1
		Unit	93.8	82.0	77.0	100	93.8	93.8	0.2
3	1950	Blr.	94.0	78.6	73.9	98.8	95.2	94.0	0
		Turb.	94.0	91.0	85.6	100	94.0	94.0	0
		Unit	94.0	91.0	85.6	100	94.0	94.0	0
	1948-50	Blr.	94.1	78.1	73.5	98.2	95.9	95.4	0.1
	(2.2 Yr.)	Turb.	94.1	89.7	84.5	99.8	94.3	94.3	0.7
		Unit	94.1	89.7	84.5	100	94.1	94.1	0.9
4	1950	Blr.	95.5	80.9	77.3	98.8	96.7	96.7	0
		Turb.	95.5	95.1	90.8	99.6	95.9	96.0	0.8
		Unit	95.5	95.1	90.8	100	95.5	95.5	0.8
	1949-50	Blr.	95.4	79.0	75.4	98.8	96.6	96.6	0
	(1.3 Yr.)	Turb.	95.4	93.0	88.7	99.4	96.0	96.1	0.6
		Unit	95.4	93.0	88.7	100	95.4	95.4	0.9
5	1950	Blr.	99.5	36.9	36.7	99.5	100	100	0
	(0.03 Yr.)	Turb.	99.5	36.2	36.2	99.5	100	100	0
		Unit	99.5	36.2	36.2	99.5	100	100	0
Plant	1950	Blrs.	95.1	75.6	71.9	99.3	95.8	95.5	0.2
		Turbs.	95.1	85.3	81.1	99.7	95.4	95.4	0.3
		Units	95.1	83.3	81.2	100	95.1	95.1	0.5
	1936-50	Blrs.	91.8	71.4	65.8	95.2	96.5	95.2	0.4
	(25.7)	Turbs.	91.9	78.6	72.5	98.0	93.8	93.8	1.2
	unit years)	Units	91.9	78.7	72.5	99.6	92.3	92.3	1.7

* Each January, for some years past, COMBUSTION has been privileged to report the preceding year's performance of Port Washington Station of the Wisconsin Electric Power Company. Although the annual heat rate of this plant, which long held the world's record, has now been bettered by other plants employing more advanced steam conditions, it still ranks near the top of the most efficient stations—*Editor.*

centralized controls of boiler and turbine auxiliaries, and apparatus to similarly centralize controls for the previous four units has been ordered. The lesser total plant personnel, including less men in the yard crew, will approximate the expected losses to military service.

Reheating Experiences

Fifteen years' life to date of 18–8 radiant reheater tubes of No. 1 boiler with 6 per cent replacement a few years ago, represents reasonably low maintenance and high reliability. The average steam temperature of Unit 1 is 833 F, and maximum temperature 1050 F. This experience suggests that the 100-deg higher steam temperatures of Unit 5 will not result in undue maintenance nor impair reheater reliability.

Superheater and reheater by-passes have been removed from all units, to improve turbine overspeed safety. They were found not necessary for starting, because furnace temperatures when starting are limited by fuel feed rate to the point that projecting bare thermocouples at the radiant superheater and radiant reheater do not exceed 1000 F. This fuel feed rate results in about 100 deg F boiler-water heating rate, which in any case would limit starting time.

Having no intercepting valve (simply two steam dump valves), Unit 5 has no battery of reheater safety valves, but simply a small warning relief valve near the gate valves used for testing the reheater.

Adding reheat units has helped system heat consumption decrease to a new low of 11,942 Btu per net kwhr for 1950, though limited reserves required more than negligible operation of older apparatus, 50,000 kw of which has full-load heat rates in excess of 30,000 Btu per kwhr, and some, consisting in part of reciprocating engines, in excess of 50,000 Btu.

Table 4

"PEAK-SHAVING" WITH OLDER APPARATUS, AND ITS EFFECT ON SYSTEM HEAT-RATE, ARE ILLUSTRATED QUANTITATIVELY.

Station	Year Installed	Pressure psig	Temp. F	1950 Generation % of system's 3,275 million kw-hr.	1950 Heat Rate Btu/net kw-hr.	Weighted Addition to Port Washington Rate, Btu/Net Kw-hr.
Com.St."A"	1903-1913	150	425-475	0.35	61,743	180
Racine	1915-1919	150	500-510	0.16	34,928	38
Lakeside	1920-1930	285-1250	650-730	25.5	14,707	1,110
E. Wells*	1938	650	800	1.75	14,054	44
Com.St."B"*	1942	1300	875	5.9	12,807	143
Port Washington	1935-1950	1250-1450	833-925	66.4	10,407	(10,407)
System	1903-1950	150-1450	575-925	100.	11,942	(11,942)

*Central heating system steam produced also

Table 3

OPERATING PERIODS AND REASONS FOR OUTAGES, 1950

Unit	No.	Operating Period Start	Finished	Hrs. Run	Kw-hr. Generated Mil.	Outages Hrs.	Reason
1	84	12-27-49*	1-6-50	254.48	13.973	42.62	Leak in water-screen tube. Delayed forced outage.
	85	1-8-50	2-17-50	957.98	58.033	.18	Safety governor mis-operation. Forced outage.
	86	2-17-50	4-15-50	1367.71	82.367	25.36	Turbine inlet valves sticking. Delayed forced outage.
	87	4-16-50	5-29-50	1040.64	54.421	30.26	Leak in rear water-wall. Delayed forced outage.
	88	5-30-50	6-16-50	408.40	24.312	206.89	General inspection and repair, boiler and turbine.
	89	6-25-50	9-9-50	1810.15	112.217	210.11	General inspection and repair, boiler and turbine.
	90	9-17-50	11-8-50	1236.54	82.707	.79	Safety-governor mis-operation. Emergency stop governor tripped. Forced outage.
	91	11-8-50	11-8-50	.40	.022	11.58	Safety-governor mis-operation. Replaced. Forced outage.
	92	11-8-50	12-26-50**	1155.89	76.287		
	Total	12-27-49	12-26-50	8232.21	504.339	527.79	
	Total	11-22-35	12-26-50	121615.64	7103.414	12720.36	
*This period started 10-23-49							
2	34	12-27-49*	6-3-50	3794.28	230.958	199.62	General inspection and repair.
	35	6-11-50	9-27-50	2604.88	169.117	82.65	General inspection and repair.
	36	10-1-50	12-26-50**	2078.57	141.761		
	Total	12-27-49	12-26-50	8477.73	541.836	282.27	
	Total	10-27-43	12-26-50	59265.05	3873.971	3868.11	
*This period started 10-30-49							
3	8*	12-27-49	6-30-50	4463.62	316.318	441.86	General inspection and repair.
	9	7-19-50	10-4-50	1861.42	137.988	81.00	General inspection and repair.
	10	10-8-50	12-26-50**	1912.10	145.286		
	Total	12-27-49	12-26-50	8237.14	599.592	522.86	
	Total	10-5-48	12-26-50	18334.25	1315.364	1157.70	
*This period started 10-16-49							
4	3*	12-27-49	3-3-50	1607.05	121.353	201.02	General inspection and repair.
	4	3-12-50	3-29-50	423.00	32.952	4.98	Generator-lead failure.
	5	3-30-50	3-31-50	43.47	2.469	32.08	Installed generator cable to replace one removed previous outage.
	6	4-2-50	8-23-50	3447.50	250.988	84.23	General inspection and repair.
	7	8-27-50	10-13-50	1137.55	91.056	27.63	Binding in safety governor.
	8	10-15-50	10-15-50	2.37	.072	40.50	Oil-pump bearing failure.
	9	10-16-50	12-26-50**	1708.62	137.726		
	Total	12-27-49	12-26-50	8369.56	636.616	390.44	
	Total	8-25-49	12-26-50	11185.86	830.727	536.17	
*This period started 10-16-49							
5	1	12-15-50*	12-18-50	66.02	1.228	1.40	Official starting.
	2	12-18-50	12-26-50**	204.13	6.624		
	Total	12-15-50	12-26-50	270.15	7.852	1.40	

*Initial operation of this unit

**Still in operation

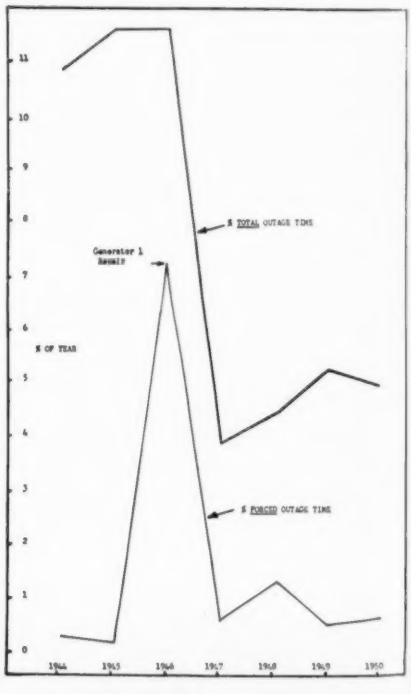

Fig. 2—Outage Time

Some Court Decisions Applicable to Power Plants

By LEO T. PARKER

Attorney at Law, Cincinnati, Ohio

RECENTLY, a plant owner inquired as follows:

"We have a law suit on our hands which we don't want to lose. We hired a contractor to install a steam boiler. He was to receive a flat contract price for the job of furnishing the materials and labor. Also, he did the work without being under our control, and hired and paid his own men. He was killed while doing the work, and his dependents are suing us for damages. Can they be compelled to accept compensation specified by the State Workmen's Compensation Act instead of suing us for damages?"

The answer is no; because only a regular employee, not an independent contractor, must accept compensation under the State Workmen's Compensation Act.

For example, in *Dubois* v. *Soule Mill*, 82 N. E. (2d) 886, it was shown that the Soule Mill made a contract with a steam fitter named Dubois to do certain work and furnish necessary materials. Dubois was to be paid a flat sum for the job. He was injured while he performed the work. The legal question was presented the court, as follows: Can Dubois sue to recover damages from the Soule Mill, or must he accept compensation under the State Workman's Compensation Act?

The higher court held that he could sue and recover damages, saying:

"If the work undertaken by the independent contractor is no part of the trade or business conducted by the principal, he may recover damages from him."

The court explained that a person is an independent contractor who does work at a flat contract price and without being under control of the employer except, of course, that the employer may demand that the completed job comply with the contract as to quality of materials and workmanship.

This court also explained that an employer need not pay social security taxes, state unemployment taxes or workmen's compensation insurance on an independent contractor. And, of course, an employer is not liable in damages for injuries to persons and property caused by negligence of an independent contractor.

Furnished Transportation

Considerable discussion has arisen from time to time over the legal question: If the owner of a plant furnishes transportation to an employee, is the latter entitled to compensation for an injury sustained while being transported?

For illustration, in *Employers* v. *Inge*, 209 S. W. (2d) 435, it was shown that the management employed several engineers and mechanics. It paid the owner of an automobile seven cents per mile to furnish transportation for the employees. One day an employee was killed in an automobile accident while returning from work.

The court held that the fatal injuries were sustained "in course of employment," and that the dependents of the deceased could receive compensation under the State Workmen's Compensation Act. It said:

"A compensable injury must be received 'in the course of employment'.... It is thought there could be little distinction between a case where the employer furnished the conveyance and where he paid for the use of the conveyance to transport his employees."

Hence it is established that an employer who furnishes transportation to an employee is liable for compensation payments or damages if the latter is injured during transportation. Also, a later court decision holds that this rule of law includes employers who furnish motor vehicles to employees.

For example, in *Travelers* v. *McCown*, 203 S. W. (2d) 663, it was shown that the company furnished an automobile to an employee and paid the upkeep, including oil and gasoline. One morning the employee attempted to start the automobile which failed to start. The morning was very cold and the fuel pump had frozen. The employee was burned while attempting to thaw it with a torch. He sued for compensation claiming that the injury arose from "the scope of his employment." The higher court held that the employee could recover compensation under the State Workmen's Compensation Act.

Of course, this rule of law is not applicable where the employee sues for damages instead of compensation under the State Workmen's Compensation Act. No damages will be awarded unless the testimony proves that the employer negligently caused the injury.

See *Wright* v. *Longhorn Corporation*, 202 S. W. (2d) 285. In this case an employee sued his employer for damages for injuries resulting from an automobile collision. The court refused to hold the employer liable because the employee failed to prove that the injury resulted from negligence of the employer.

Who Owns Patent?

Discussion has arisen from time to time over the question: If an employee obtains a valuable patent, who owns the patent? The answer is: The employee owns it, unless the employer proves (1) that the employee was hired to experiment and devise new inventions; or (2) that the employee perfected the invention during the time he was being paid by the employer.

For example, in *Drew* v. *Reinhard*, 74 F. Supp. 574, the testimony showed that one

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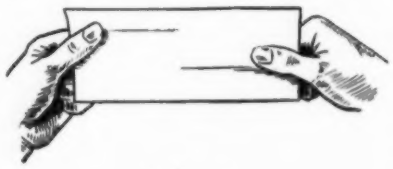
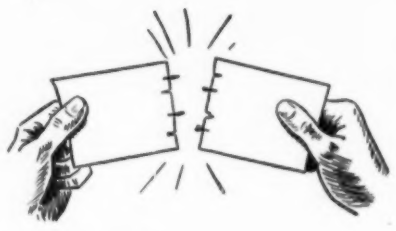


Now cut two pieces 3" wide by 5" long and join them together with staples. Pull this spliced strip just a little and it pulls apart.



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Reinhard was employed to establish methods of analysis and control of boiler water. Also, he handled salesmen's reports, and had something to do with the watching of expenses, costs, etc. During the employment he made a valuable invention. The question was presented to the court as to who owned the patent, Reinhard or his employer?

The court held that Reinhard was legal owner of the patent because the employer failed to prove that Reinhard had perfected the invention on the employer's time. It said:

"One employed to make an invention who succeeds, during his term of service, in accomplishing that task is bound to assign to his employer any patent obtained. The reason is that he has only produced that which he was employed to invent.... It is quite clear that he (Reinhard) was not employed to develop an invention, nor did he agree to assign any invention that he might make during the period of his employment."

For comparison, see *American Company* v. *Hubbell*, 3 Cir., 76 F. (2d) 807. Here the higher court held that the employer owned an employee's invention because the testimony showed that the latter was hired to experiment and also he had signed a contract whereby he bound himself to "assign to this company all property rights of any inventions" connected with the work of the company.

Recently a higher court was asked to decide this question: If a manufacturer receives from the owner of a patent a license to manufacture a certain type engine, what is the remedy of the inventor if the manufacturer enlarges the scope of his license without consent of the owner of the patent?

In *Lanova Corporation* v. *Atlas Imperial Engine Company*, see 55 Atl. (2d) 272, it was shown that a corporation owned certain patents on engines. These patents were referred to as the "Lanova Combustion System." This corporation entered into a license agreement with a manufacturer. Later the manufacturer utilized the patents on types of engines not specified in the license contract. The higher court held that the owner of the patent could not sue and recover additional royalties, but must sue the manufacturer for infringement of the patent. It said:

"If the defendant (manufacturer) should use the patents over and above the limitation, the plaintiff (patentee) would have no remedy under the contract but could sue for infringement. The success of its suit would depend solely upon the validity of the patents."

Simple Furnace Patent Valid

According to a recent higher court, simplicity of an invention will not prevent the inventor from being awarded a valid patent.

In *Hubbell*, 164 Fed. (2d) 700, it was shown that an inventor corrected or improved industrial furnace walls which ordinarily were made by using firebricks between each layer of which cement was placed. This kind of built-in liner had a comparatively short life because, as the

flame traveled over its irregular surface, the cement in the joints was caused to disintegrate and be swept away. Such conditions also affected the life of the crucible which became eroded from the impact of the direct flame. The inventor filed an application for a patent on a furnace liner which comprises an outer shell of noncombustible material into which is placed another liner. The main invention consisted of the liner being formed of a single piece of refractory material having smooth and unbroken exterior and interior wall surfaces.

The Patent Office examiner refused to award a patent on the grounds that the liners are old, and it would not be inventive to glaze the lining. The Federal Court disagreed, however, and held that Hubbell's invention was patentable. It said:

"When considered in the light of its accomplishment and the state of the prior art, its simplicity is the determining factor that brings us to the conclusion that the exercise of the inventive faculties was required to produce it, and that it was not obvious to one of ordinary mechanical skill.... We think in cases where the article produced is novel, useful, and not anticipated it should be regarded as involving the element of invention, notwithstanding the simplicity of the invention."

Also, in *Potts* v. *Creager*, 155 U. S. 597 the Supreme Court of the United States said:

"The apparent simplicity of a new device often leads an inexperienced person to think that it would have occurred to any one familiar with the subject; but the decisive answer is that, with dozens and perhaps hundreds of others laboring in the same field, it had never occurred to any one before."

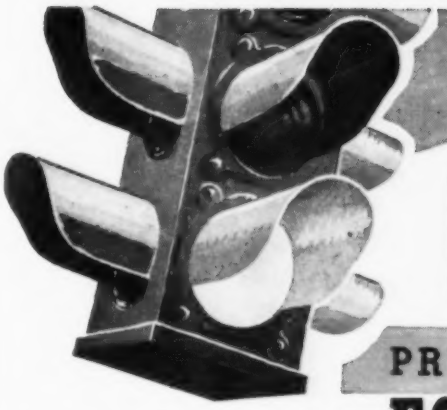
State Taxation

Considerable discussion has arisen over the question as to whether a steam plant, or part thereof, or other products, are subject to taxation by authorities in the state in which they are situated if intended to be shipped outside the state.

For illustration, in *Empresa Siderurgica, S.A.* v. *County of Merced*, 69 S. Ct. 995, the testimony showed facts, as follows: Equipment of a steam plant in California was sold to a corporation in Colombia for export. The title to the plant passed to the purchaser in the foreign country at once. After 12 per cent of the plant had been shipped out of the country the California state tax authorities levied taxes on the value of the balance of the plant.

The purchaser of the plant appealed to the Supreme Court of the United States contending that it was not liable for payment of taxes to the state of California in which the plant was situated because it was being made ready for shipment out of the state and also title to the plant had already passed to the purchaser who lived outside this country. The Supreme Court held that the purchaser must pay taxes to the state, and said:

"Goods do not cease to be part of the general mass of property in the state, subject to taxation in the usual way, until they have been shipped, or entered with a common carrier for transportation, to another state, or have been started upon

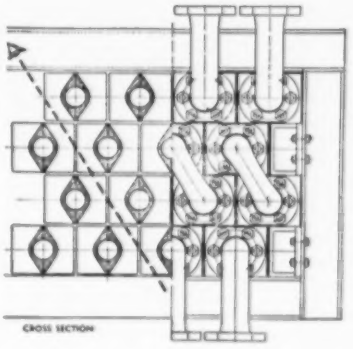


GREEN

PREMIER DIAMOND

ECONOMIZERS

The Economizer with the "Diamond" Design



Here are the four major values in the "diamond" shape of the Green Fuel Economizer:

1... Streamline flow of flue gases gives minimum draft loss

2... Finned tubes give maximum heating surface in given space

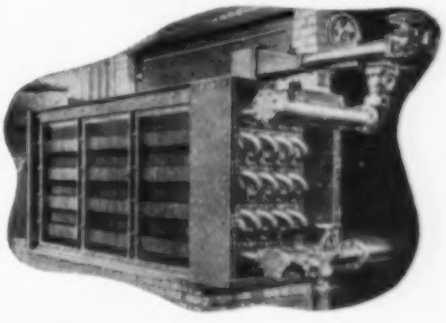
3... Staggered tube arrangement permits easy inspection

4... Minimum soot collecting surface is thoroughly cleaned by Green's "Special" Soot Blowers

Green Premier Diamond Economizers are available in either cast iron tube construction (Type 25) or steel tube construction (Type 12).

Pressure parts are rugged and joint flanges independent of support flanges.

Green Fuel Economizer's reputation of 60 years assures you of satisfactory performance and quality. Send for Bulletin No. 169.



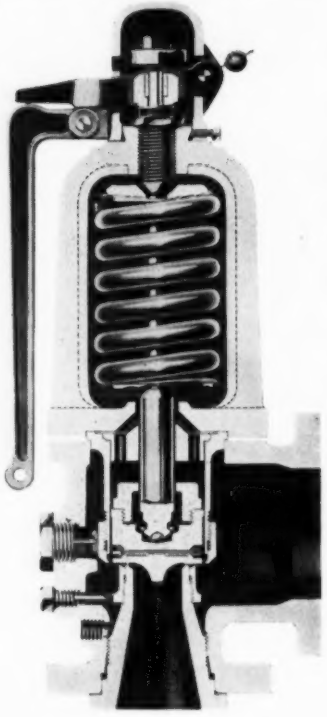
THE GREEN Fuel Economizer COMPANY INC.

BEACON 3, NEW YORK

ECONOMIZERS • FANS • AIR HEATERS • CINDERTRAPS

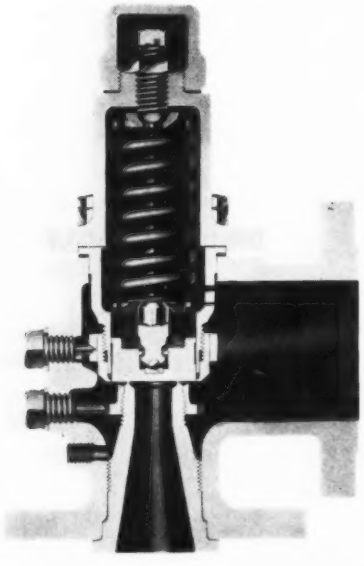
CROSBY *for safety and dependability!*

CROSBY SAFETY VALVES—*Styles HN & HS*



STYLE HN—Steel safety valves for high pressure and temperature steam service. Their high discharge capacity reduces to a minimum the number of valves needed. Full nozzles and discs are forged from stainless steel. Flanged inlet and outlet. Welded inlet of unique and superior design also available. Fully exposed springs with exclusive cooling spool feature. Pressure to 2500 lbs., temperature to 1100 F. Sizes 1½" to 4".

STYLE HS – Steel safety valves for medium pressure and temperature steam service. Same general construction as HN. Pressure to 600 lbs., temperature to 900 F. Sizes 1" to 6".



CROSBY RELIEF VALVES—*Style JO*

Crosby manufactures a wide variety of high quality relief valves in many sizes. Each provides accurate, dependable service and requires minimum of maintenance.

STYLE JO Valves are furnished in all Orifice sizes; Inlet sizes from 1" to 6".

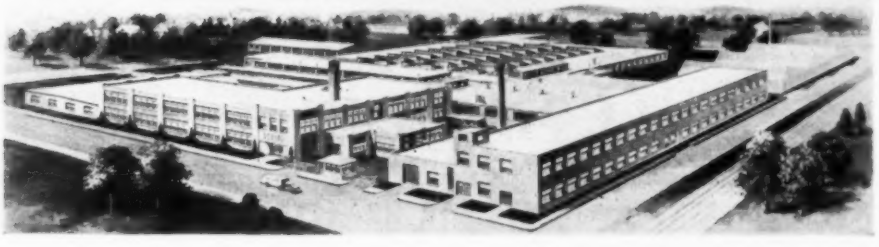
Cast Steel Valves are furnished for temperatures to 800 F.; Alloy Steel Valves to 1100 F. All of these types have forged stainless steel **FULL NOZZLE** construction.

Cast Iron Valves with semi-nozzle construction available for 400 PSI – 100 F., or 250 PSI–450 F.

Crosby also manufactures precision indicating and recording gages

Where high pressures, rapid pulsation and vibration quickly wear out ordinary gages, Crosby heavy-duty precision gages can be depended on for exceptional accuracy and long life because of their rugged construction and time-tested precision-geared movements. For this reason, they meet the most exacting requirements, for power plant use, and for wide service in the petroleum and processing industries.

CROSBY STEAM GAGE & VALVE COMPANY
43 Kendrick Street, Wrentham, Mass.
District Sales Offices:
BOSTON·NEW YORK·CHICAGO·DALLAS·LOS ANGELES



such transportation in a continuous route or journey."

The court also explained that this same rule of law is applicable to all merchandise. In other words, if merchandise is not already started on movement to a point outside the state, on the state's tax date, such merchandise *is* subject to taxation by the state.

Sales Tax Law

Another interesting tax question that has arisen is whether coal and fuel oil used to generate steam for process and power is subject to taxation under a sales tax law.

In *Phillips & Buttorff Mfg. Company* v. *Carson*, 217 S. W. (2d) 1, a state law was litigated which exempts from sales tax all materials used for processing articles for resale where such materials become a component part of the finished product. This question was presented to the court: Are coal and fuel oil exempt from taxation when used for generation of steam and power employed in manufacturing articles for wholesale and retail sale?

The higher court refused to exempt coal and oil from state sales taxation, saying:

"We think that coal and fuel oil, purchased for use by the complainant in operating generators and other machinery, are used indirectly in that they produce steam, which gives power to generators and which in turn set in motion machines of different kinds in fabricating articles to be sold to the ultimate consumer."

Nuisance from Noise and Vibration

When and under what circumstances an owner of private property is entitled to recover damages for vibrations caused by engines or other equipment appears to be a matter that only a jury can decide. This is illustrated by the following case.

In *Friedman* v. *Forest City*, 30 N. W. (2d) 752, the testimony showed that in 1930 one Friedman purchased a home in a residential section. In 1939 the city constructed an electric plant across the street from Friedman's home. Alleging that vibrations and noise from the engines in this plant cracked the walls of his home and interfered with its comfortable enjoyment, Friedman brought suit against the city and asked the court to grant him damages against the city.

The higher court refused to award damages or to grant an injunction against further operation of the plant, and said:

"The defendant here is a public service corporation furnishing light and power to the public, and cannot abandon its public service without consent of the public service commission. The power plant is permanently located, costing many thousands of dollars. The injury is not abatable. The public service corporation must continue its service.... He (Friedman) knew or should have known also that the closing of the plant by court order was almost beyond the realm of possibility."

For comparison, see *Finn* v. *Pasquini*, 58 Atl. (2d) 199. Here certain home owners filed suit against a company and asked the court to grant an injunction prohibiting operation of the plant because the machinery vibrated excessively.

The court held that the company could continue to operate its engines and machines if it placed rubber mats or other sound-deadening material under the engines or between vibrating metal parts of the machines to reduce the noise to a minimum.

Don't Neglect Permit

Sometimes the management of a company contemplating alterations or addition of new equipment neglects to obtain a permit before starting construction. This is a risky procedure. Although city officials may with honest intentions promise to issue a permit in violation to a city zoning ordinance, such promise definitely cannot be fulfilled.

For example, in *Duffcon Products, Inc.* v. *Borough of Cresskill*, 64 Atl. (2d) 347, the testimony showed facts, as follows: A city council passed a zoning ordinance in which a certain area was zoned against use of limited power in any fabricating, manufacturing, converting, altering, finishing or assembling plant. The Duffcon Products purchased land in this restricted area, filled it in at a cost of $6000, and constructed an addition to the plant without obtaining a permit. The attendant noise, vibration, dirt and dust was considerable and, in addition, trucks moving to and from the site caused traffic snarls during certain periods of the day on the county highway bordering the tract. Two months later the company applied for a permit to operate the plant in this area. The city officials refused to grant the permit, but the lower court ordered the city officials to issue the permit. Later the higher court reversed the lower court and held that the company could not receive a valid permit to operate its plant unless the city council amended the ordinance to include the company's business. This court said that once the powers of the city officials are outlined in a zoning ordinance, the ordinance may not be circumscribed, altered or extended by municipal officials. The court said:

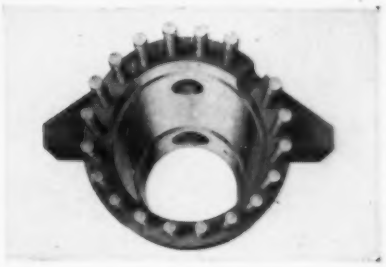
"Sound social, economic and governmental policy dictates a separation, where possible, of residential areas and industrial areas.... Once the board of adjustment is provided for in the zoning ordinance, its powers stem directly from the statute, and may not in any way be circumscribed, altered or extended by the municipal governing body."

Another important point of law decided by this court is that once a manufacturing plant is established and in operation in an area, new zoning ordinances cannot be enacted which will stop, vary or limit prior operations of the company. In this respect, the court said:

"In the case of our older and fully developed communities, it is now too late to do more than preserve such beneficial features as may have survived the period of spontaneous and uncontrollable growth. Proper zoning today, however, can do much in our newly developing communities to provide and to maintain safer and more healthy living conditions."

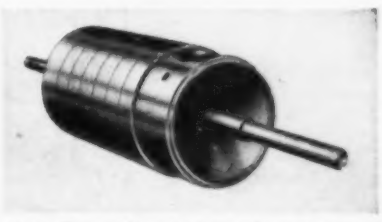
Here's how your high pressure Boiler Feed Pump is Precision Built by Pacific

1 The steel forging for the outer case is thoroughly annealed.

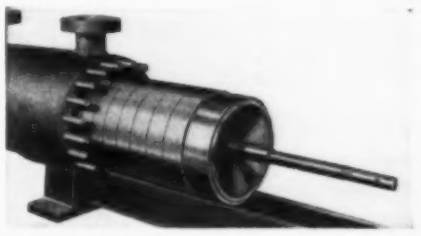


2 The outer case is precision finished.

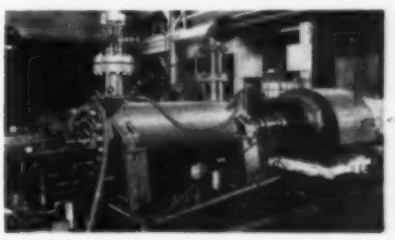
3 The diffusers and impellers are chrome alloy steel—impellers dynamically balanced.



4 The unitized internal assembly is assembled outside the case. All parts are precision finished.



5 The unitized internal assembly is installed in the outer case.



6 The pump is completely assembled—then performance tested.

7 Following test, pump is dismantled; checked; inspected; reassembled

8 A precision-built, performance-tested, inspected Pacific Pump is on its way!

PACIFIC *Precision Built* PUMPS

Bulletin 109 Gives Details

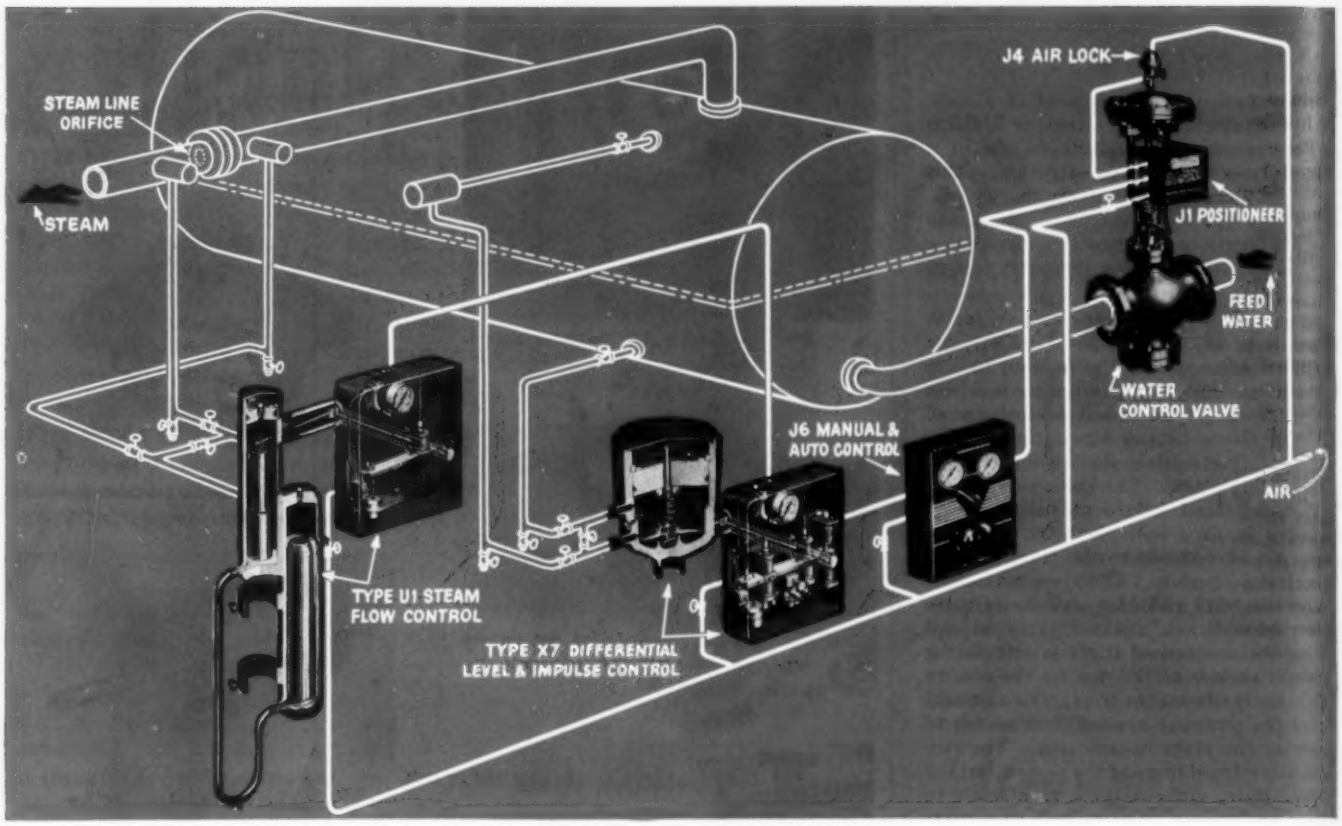
Pacific Pumps inc.

ONE OF THE DRESSER INDUSTRIES

HUNTINGTON PARK, CALIFORNIA

BF-6 *Export Office:* Chanin Bldg., 122 E. 42nd St., New York ★ *Offices in All Principal Cities*

Swartwout Impulse Regulation assures correct feed water supply under any load condition



SWARTWOUT two-element controls—by utilizing the very forces that cause false drum level—produce a corrective impulse that assures correct level even under rapid load swings. Since "shrink" and "swell" are functions of *rate of change,* as well as magnitude of load, only Impulse Regulation gives satisfactory operation under *any rate of change in load of any magnitude.*

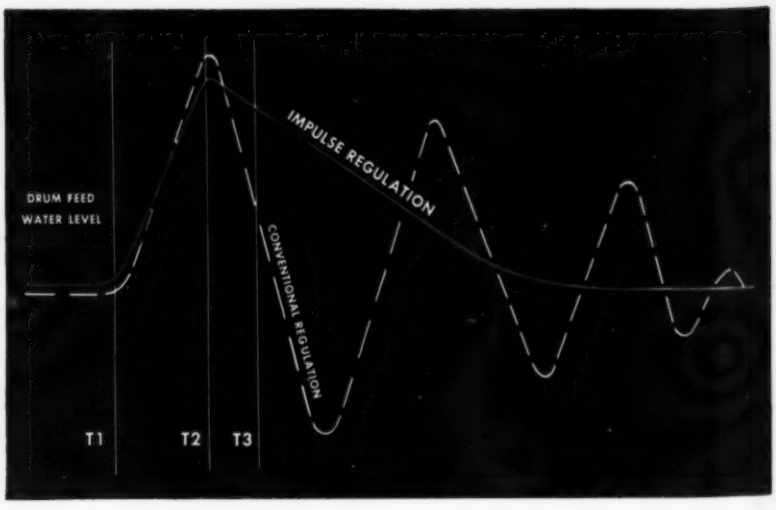
Type U1 flow transmitter takes square root of steam line orifice differential and feeds airloading pressure, which is directly proportional to steam flow at all flows, to X7 differential level and impulse control. X7 unit positions flow valve by sending airloading pressure which is result of combining *rate of change* of steam flow function with water level.

Graph *(right)* shows how proper combination of these forces, plus reset and setback features, assures that valve will give desired operation under *any* load condition. System can be adjusted to maintain drum level constant at all loads, carry it high at high loads, low at low loads, or vice versa. In addition to this FW6 two-element system, Swartwout also makes an FW7 three-element impulse regulating system. Other types include FW5 single-element system and SC (FW1) thermo-hydraulic system.

A-3753

Swartwout

POWER PLANT EQUIPMENT



SEND FOR BULLETINS S-27, S-20-E • THE SWARTWOUT COMPANY, 18511 EUCLID AVENUE, CLEVELAND 12, OHIO

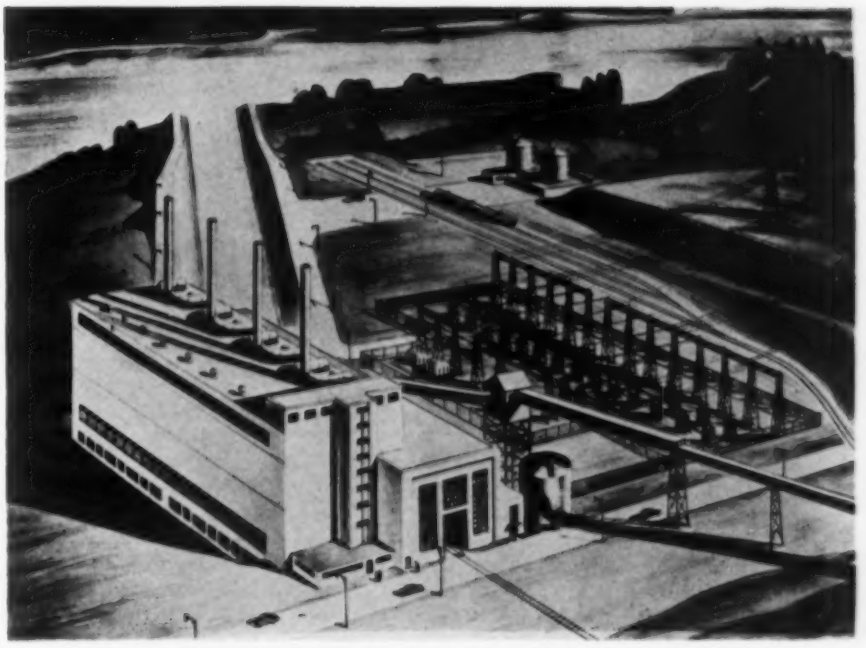
Large Power Station for India

The accompanying illustration is an architect's sketch of the Bokaro Power Station now under construction about 200 miles northwest of Calcutta. With a designed capacity of 240,000 kw it will be the first high-pressure steam-electric generating station in India and forms a part of the Damodar Valley Project in conjunction with a series of eight dams for hydro power, irrigation and flood control. Smaller but comparable in concept to our own T.V.A., it is a part of Prime Minister Nehru's long-range plan for the industrial development of India.

Local Coal to be Burned

There will be six 300,000-lb per hr, two-drum Combustion Engineering-Superheater steam generating units fired with pulverized coal and operating at 950 psi, 900 F. One of the biggest strip coal mines in the world, the Bermo coal field, is located only three miles from the plant. This coal averages about 10,750 Btu per lb.

Contract for the design, engineering and construction of the Bokaro Station was awarded to the Kuljian Corporation of Philadelphia, under whose direction a group of Indian engineers have for several months past been studying operating practices in a number of American central stations and visiting the plants of the major equipment manufacturers. Upon their return to Bokaro they will work closely with the Kuljian staff now supervising construction of the plant and will ultimately assume responsibility for its operation after a year's initial operation by the American personnel.



Bokaro, the first high-pressure steam-electric power station in India

Joint Public-Private Networks To Power New Atomic Energy Plant

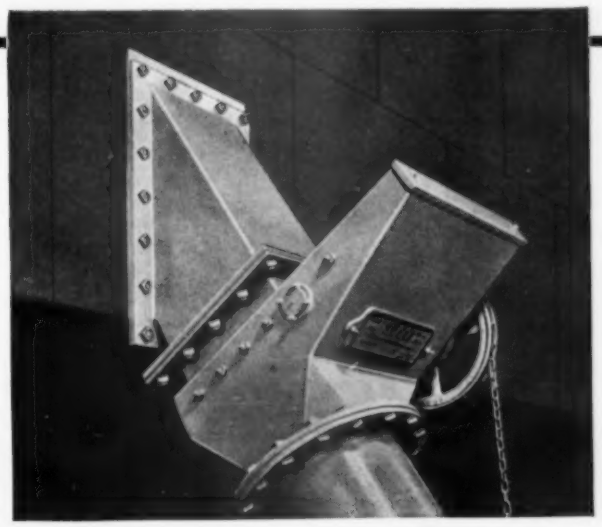
The Atomic Energy Commission is working out arrangements with the Tennessee Valley Authority and a syndicate of five privately owned public utility firms whereby the public and private power networks would jointly supply electric power to the projected new AEC installation on the site of the former Kentucky Ordnance Plant near Paducah.

The new AEC production plant, which will produce uranium-235 by a gaseous diffusion process, will eventually have power requirements far beyond the generating capacity of facilities now operated or planned by the utilities serving the West Kentucky area.

Under tentative agreements with the TVA and the syndicate of private companies, known as Electric Energy, Inc., each would supply approximately half of the total power needs. The five companies in Electric Energy, Inc. are Central Illinois Public Service, Illinois Power Company, Kentucky Utilities Company, Middle South Utilities, Inc., and Union Electric Co. of Missouri.

Under the plan adopted by the Commission, both the TVA and Electric Energy Inc. would build new steam generating facilities, located in such manner as to provide the maximum security and to assure the most dependable supply of power to the new AEC plant. The generating and distribution systems of both TVA and of the five private companies would be so interconnected as to provide for the use of the total power resources of all systems and to permit economic interchange of power to utilize periodic surplus power from the new generating stations.

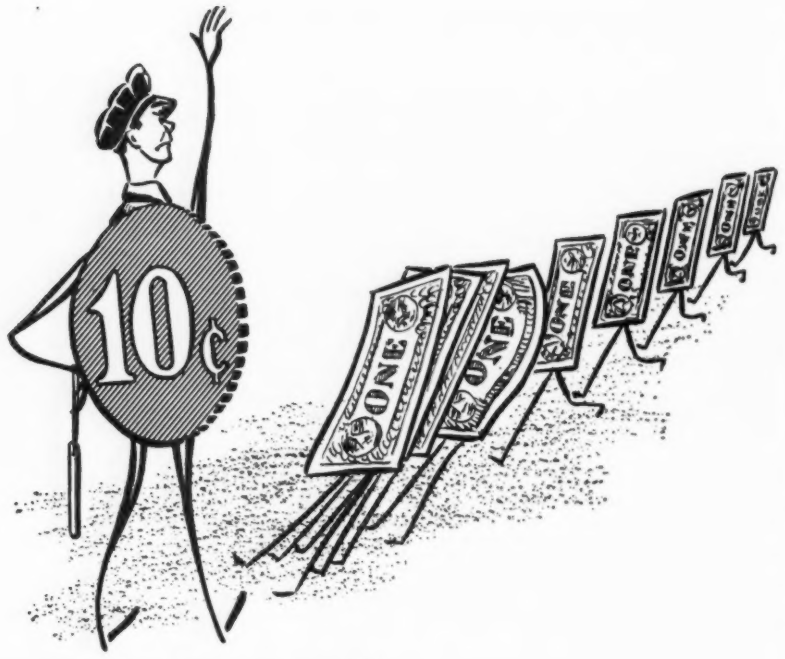
It is believed that two new generating plants to be built as part of entirely different power networks would give greater assurance of continuing supply.



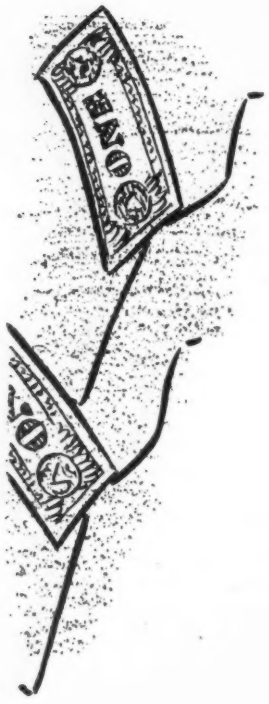
S-E-CO. COAL VALVES can be made for installation in an inclined position, as shown in photograph. In some plants if coal valves are installed in this position, a considerable saving in headroom results. These valves are equipped with a disc brake so that they are not self-closing.

Your inquiry would be appreciated.

STOCK EQUIPMENT COMPANY
715C Hanna Building ★ Cleveland 15, Ohio



"A DIME SPENT NOW *on proper design*
CAN STOP THE MARCH
of wasted coal dollars".



EQUIPMENT LASTS FOR YEARS
COAL FOR SECONDS

Fairmont Coal Bureau Engineers have the facts and figures on hundreds of plants that have been designed to efficiently burn Fairmont Low Fusion Coal.

Their "know-how" applied to your problem might result in lower steam costs for you.

Write today and have your name placed on our mailing list.

FAIRMONT COAL BUREAU
FAIRMONT REGION
WEST VIRGINIA
SERVICE TO INDUSTRY

MAIL COUPON TODAY!

FAIRMONT COAL BUREAU, Chanin Bldg., 122 E. 42nd St., New York 17, N. Y.

Kindly place me on your mailing list to receive copies of your publications and Technical Reference Bulletins.

C-1-51

Name _____ Company _____

Position _____ Nature of Business _____

Address _____ City _____ Zone _____ State _____

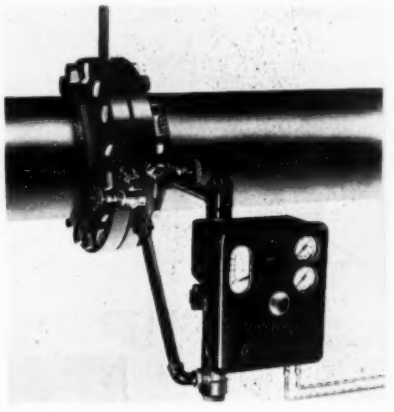
New Equipment

Air Separators

A line of separators for cleaning compressed air ranging in inlet and outlet tapping sizes from $^1/_2$ in. to $2^1/_2$ in. is announced by the Swartwout Co. Cleveland, Ohio. Known as the Airfuge, the separator is said to be capable of removing 99 per cent of impurities without pressure drop, operating by centrifugal force. A float-operated trap automatically releases accumulated liquids as they rise to a level above that necessary to effect a seal.

Kinetic Manometer

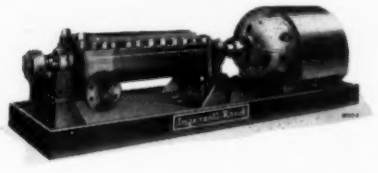
Fischer & Porter Co., Hatboro, Pa., have developed the V/A Cell which is a precision-flow transmitter for differential-pressure applications. It is basically a through-flow instrument of the variable-



area type and measures a bypassed portion of the main-line flow. The cell is applicable to services on liquids, gas and vapor streams including steam.

Centrifugal Pumps

Announcement of a line of completely new multi-stage pumps for high-pressure applications to 1200 psig and capacities to 1600 gpm has been made by the Ingersoll-Rand Co., Phillipsburg, N. J. Known as the Class HMTA, they are built in 3-, 4-, 5- and 6-in. sizes with from 3 to 9 stages. Applications cover a wide range of boiler feed, pipe-line pumping and refinery uses as well as other general high-pressure

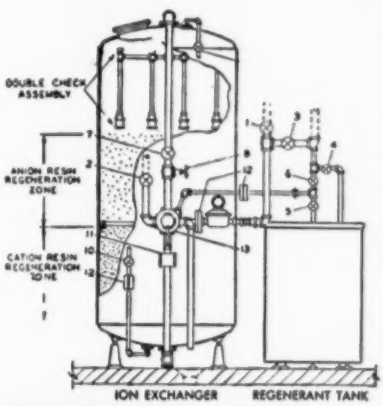


industrial services. The pressure differential between successive stages is sealed by corrosion-resistant cast-iron or alloy-steel piston rings around the outer diameter of the channel rings. Multiple-volute de-

sign which eliminates radial thrust at all conditions of operation is said to assure a completely balanced rotor. A hydraulic balancing drum counteracts axial thrust.

Single-Tank Deionizer

Elgin Softener Corp., Elgin, Ill., has designed a single-tank deionizer which is said to be capable of delivering water having a specific resistance above 5,000,000 ohms, or ten to 100 times greater than most distilled water. The two resinous zeolite exchangers are intermixed in a

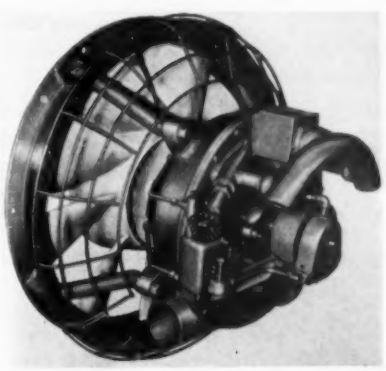


1 HARD WATER INLET VALVE
2 DEIONIZED WATER OUTLET VALVE
3 SOFT WATER INLET VALVE
4 REGENERANT MAKEUP VALVE
5 REGENERANT SUCTION VALVE
6 REGENERANT RINSE VALVE
7 UPPER MANIFOLD VALVE
8 MID-MANIFOLD VALVE
9 AIR VENT VALVE
10 AIR INLET VALVE
11 EFFLUENT QUALITY CONTROLLER
12 RATE OF FLOW INDICATORS
13 MULTIPORT VALVE

single tank, and because of their marked difference in density they can be divided by backwash into two zones for separate regeneration. In one piece of equipment the water is deionized; the zeolite mixture is separated into its components; and the two resins are regenerated, remixed and again returned to the deionizing cycle.

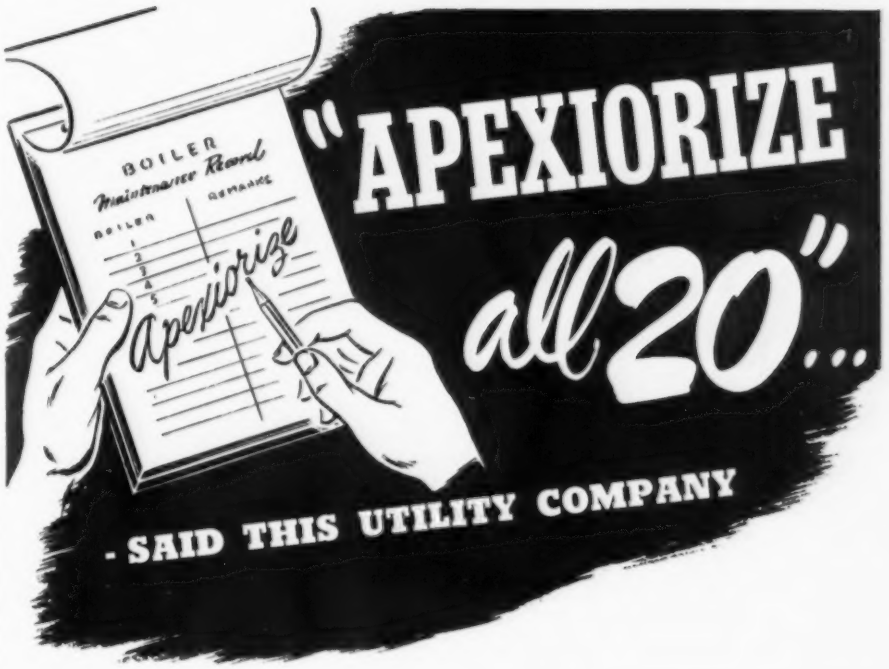
Turbine Blowers

L. J. Wing Mfg. Co., Linden, N. J., has announced a line of turbine blowers with all-steel turbines suitable for steam conditions up to 600 psig, 750 F. The blowers



have been modernized with fan impellers of true airfoil design and streamlined air entry, providing high efficiency and quiet operation. They may be bolted directly

(*Continued on page 51*)



And with the project already half completed, this company's central station steam-generating units will soon be internally protected with Apexior Number 1 surfacing.

Why are these and scores of other high-temperature, high-pressure units constantly being added to the ranks of Apexiorized boiler steel?

We could give you many reasons. For one, there's the matter of proper protection if you're considering chemical cleaning. Apexior saves metal by preventing acid contact. Because it discourages deposit formation and bonding, it also permits easier, quicker cleaning.

Basically, though, there's just one reason for Apexiorizing any boiler and that is to build into it an operating factor of safety not otherwise obtainable. With Apexior guarding internal surfaces, an expendable maintenance item — not costly metal — becomes your first line of defense. Should operating conditions deviate for any reason from the ideal, Apexior takes the consequences while steel, safely isolated, retains all of its initial strength and soundness.

Apexiorizing is a simple, inexpensive way to make a good boiler better — something we've been specializing in now for thirty-three years. Our 8-page Bulletin 1530 gives you all the facts — and if you'll give us the necessary data on your boilers when you write (number and size of tubes and drums), we'll be happy to include a quotation.

MAINTENANCE FOR METAL

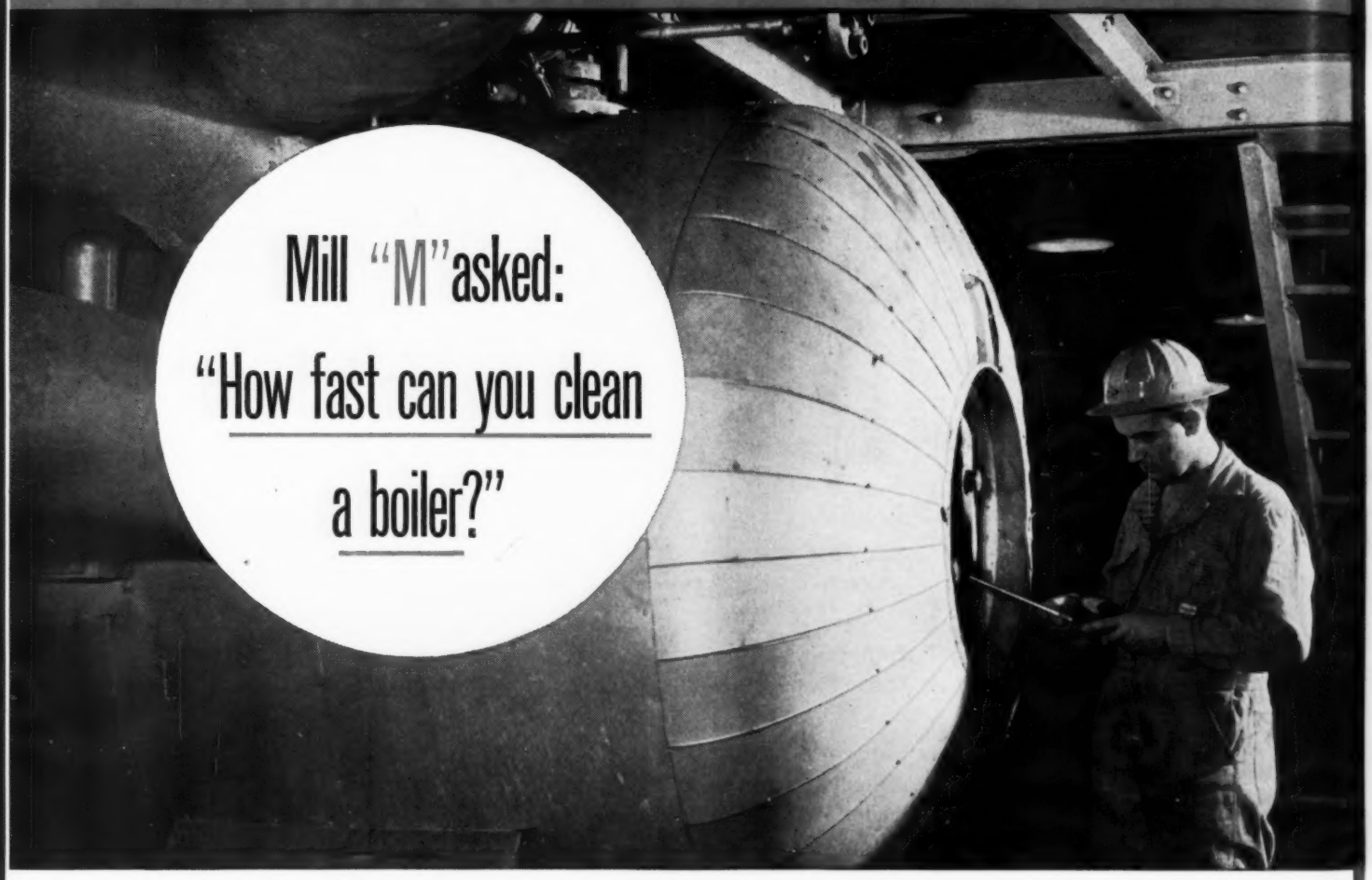
THE DAMPNEY COMPANY OF AMERICA

HYDE PARK, BOSTON 36, MASS.

114-1

DOWELL SERVICE

CHEMISTRY APPLIED TO MAINTENANCE CLEANING PROBLEMS



Dowell Service cleaned the internal surfaces in 10 hours!

This was the case of a boiler generating 350,000 pounds of steam per hour with an operating pressure of 1250 p.s.i. In ten hours Dowell Service removed an estimated 1,000 lbs. of deposits which were causing tube failures. The boiler was back on the line the next day.

What is Dowell Service? It is simply the application of chemistry to the problem of removing deposits from heat exchangers, water lines and all kinds of process equipment. Dowell engineers fill the equipment with liquid solvents which reach wherever steam and water flow and are designed to dissolve and disintegrate the deposits efficiently and quickly. Dismantling is not necessary.

Somewhere in your plant there is a job that can be done *faster, better, more economically* by Dowell Service. Let an experienced Dowell Service Engineer help you with your maintenance planning. No obligation, of course.

Other recent Dowell jobs:

Entire Piping Systems **of two college dor tories cleaned of scale.**

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Three Formaldehyde Contact Towers **Reboilers cleaned and restored to design operating efficiency.**

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Six Black Liquor Evaporators **cleaned paper company. Deposits removed fr vapor and liquor sides in one operati**

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to the front windbox for oil burner applications or may be cemented into the boiler brick work. The units come in capacities to 70,000 cfm or statics to 20-in. w.g.

Blow-Off Valve

An addition to the line of valves manufactured by the Everlasting Valve Co., Jersey City, N. J., is a Straightway "Y" type valve built in conformity to the A.S.M.E. Boiler Code. Both the head and the renewable seat are made of monel metal, and the stem is of stainless steel. These valves are offered in $1^1/_2$-, 2- and $2^1/_2$-in. sizes in cast iron or cast steel for pressures up to and including 600 psig.

Canvas Covering

A new canvas covering called Texad for boilers and industrial furnaces has been developed by the Bigelow-Liptak Corp., Detroit, Mich. The new material combines a plasticized synthetic resin emulsion, used as an adhesive, with strips of lightweight canvas. The covering seals shrinkage cracks in the finish coat of insulating cement and tends to prevent air leakage caused by the porosity of the insulation. It may be used to protect outdoor boilers against weather, and on inside installations the material may be washed when desired.

NEW CATALOGS AND BULLETINS

Any of these may be secured by writing Combustion Publishing Company, 200 Madison Avenue, New York 16, N. Y.

Boiler Water Treatment

The Power Chemicals Division of E. F. Drew & Co. has made available a booklet describing their complete boiler water treatment. The bulletin includes pictures, illustrations and a comprehensive description of the methods prescribed for eliminating boiler deposits.

Condenser Circulators

Condenser circulators in standard sizes to 100,000 gpm and in special sizes to 200,000 gpm are illustrated in Catalog No. G-1050 issued by Economy Pumps, Inc., Division of Hamilton-Thomas Corp. Designed for power station service, the pumps are vertical mixed-flow units of large capacity and low head and are designed to handle water ranging in chemical analysis from fresh river water to contaminated harbor or sea water. New "pull-out" type units are also shown.

Blow-Off Valves

Yarnall-Waring Co. has issued Bulletin B-433 which gives revised details on Yarway blow-off valves for high-pressure boilers. Construction features, dimensions, materials specifications and details, and typical installations are given for Type C seatless valves, hard-seat valves and unit-tandem valves.

Ash and Fly-Ash Handling Systems

A 24-page booklet offered by Beaumont Birch Co. gives detailed information on both hydraulic and pneumatic ash and fly-ash handling systems. Compiled in question and answer form and interspersed with actual schematic drawings of specific arrangements, the booklet discusses the elements and advantages of the various systems.

Explosion-Proof Motors

Bulletin SL300-5, prepared by the Elliott Company's Crocker-Wheeler Division, illustrates a line of explosion-proof motors for use in hazardous locations. There is a cutaway view of a motor and photographs of the stator, end shields, fan and cowl, rotor, conduit box and bearings. The "Sealedpower" explosion-proof design is available in N.E.M.A. frames in ratings up to 100 hp.

Motor Bearings

Pre-lubricated bearing design is the subject of a four-page bulletin, B-2201, recently published by Reliance Electric and Engineering Co. The illustrated folder contains descriptive sketches, cutaway drawings of improved double-shielded bearings and bracket mountings, and a check list of comparative bearing-arrangement design features.

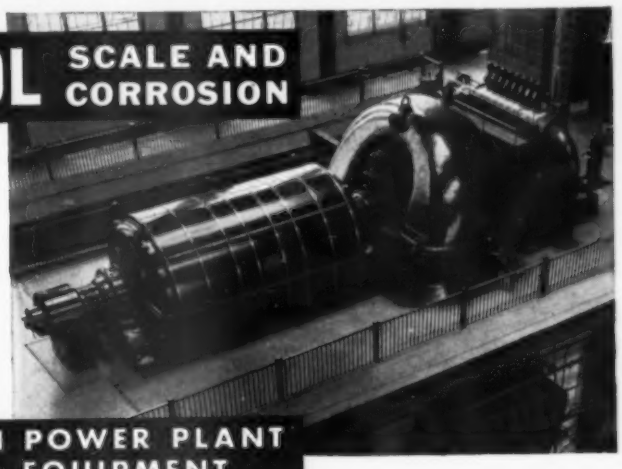
Non-Return Valves

Cushioned triple action non-return valves for installation in steam headers are described in an eight-page bulletin published by Golden-Anderson Valve Specialty Co. Included are a complete technical description, engineering diagrams of three different body and yoke patterns, a parts list, and operation and installation instructions.

Regulators

A four-page folder giving useful information on temperature regulators, pressure regulators and desuperheaters is available from Spence Engineering Co.,

CONTROL SCALE AND CORROSION



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Inc. In addition to data and illustrations of 27 pilot-operated regulating valves, there is an explanation of operating methods.

Zeolite Softener

Cochrane Corp. has just issued Publication 4505 on Cochrane Junior Industrial Zeolite Softeners. This illustrates and describes a water softening apparatus suitable for use in small boiler plants requiring softened water in a quantity less than 100 gpm. Drawings, dimensions and capacities are shown.

Power Equipment

An attractive 28-page bulletin which briefly presents products commonly used for power generation, transmission and distribution systems has been released by Allis-Chalmers Manufacturing Co. Included under generation are steam and hydraulic turbines, generators and auxiliary equipment such as condensers, pumps and water conditioning apparatus. Other sections are devoted to electric power distribution and control equipment.

Temperature Indicators

Bulletin 404 issued by Manning, Maxwell & Moore, Inc., introduces a new line of Microsen temperature indicators and recorders. Included in the 12-page bulletin is an explanation of the principle employed to balance forces of thermocouple input and mechanical position of the instrument pointer. Design features, thermocouple materials and ranges, principal dimensions, and typical applications are also listed.

Motor Generators

An eight-page, two-color booklet, GEA-5506, covering motor-generator sets from 30 to 8000 kw has been made available by the General Electric Co. Well illustrated, the booklet shows four typical installations and describes construction features of synchronous motors and d-c generators.

Water Treatment

National Aluminate Corp. has published a four-page bulletin entitled "The Nalco System of Water Treatment as Applied to the Modern Self-Contained Boiler." The bulletin describes a service contract plan in which "package" boiler users are able to participate in a manner similar to the water treatment programs of large central stations.

Industrial Unit Heaters

Bulletin No. 10, the Standard Code for Testing and Rating Steam Unit Heaters, Second Edition, has just been released by the Industrial Unit Heater Association. While the fundamental engineering has not changed since the first edition of 1930, there have been marked improvements in testing equipment, instruments and techniques, details of which are incorporated in the new 19-page bulletin.

Longer Service Life for Fan Housings

Despite Highly Abrasive Gases, Housings Show No Wear After Many Months of Hard Service

Because of the flow of fly ash at high velocity, the inside of the induced draft fan housing takes a severe beating due to erosion, particularly at the inlet boxes. Various refractory materials used in this equipment wear out in from 2 to 3 months, resulting in costly time loss and repairs.

A prominent public utility finally tried R & I Super #3000 Refractory Cement. This remarkable, easily mixed mortar was troweled to a ⅝" to ¾" thickness over expanded metal lath tack-welded to the inside of the housing. It air set to flint hardness. When inspected after 6 months of continuous, hard service, it showed absolutely no wear or cutting effects. Today, 10 months after its application, it is still in excellent condition.

Super #3000 is easy to apply and has remarkable resistance to all conditions at temperatures up to 3000°F. It permanently bonds new brickwork weld-tight and patches cracked, broken or eroded refractory surfaces, making them stand up indefinitely under the severest kind of service. As a longer-lasting refractory applied over insulation inside the ducts. Super #3000 also greatly increases duct life.

Investigate Super #3000—one of the R & I complete line of better refractory cements. Write for Bulletin R-53.

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Mechanical Draft Fans

An extensive line of forced and induced draft fans is described in a new catalog (Bulletin No. 168) issued by The Green Fuel Economizer Co., Inc. Containing 20 pages illustrated with drawings of typical fan types and photographs of representative installations, this two-color booklet also includes performance curves and details of construction features, drive arrangements and mounting methods.

Water Clarification

Bulletin No. 5001, published by the Cochrane Corp., describes a water-conditioning apparatus known as the Cochrane Liquon Sludge Contact Reactor. . In addition to detailing basic principles the bulletin describes the operation of the unit, illustrates the types of equipment available, gives a list of applications, and lists the auxiliary equipment. Photos of typical installations are also shown.

Synchronous Condensers

A 16-page bulletin (No. 05B7285) has been prepared by Allis-Chalmers Mfg. Co. to cover air-cooled, outdoor air-cooled and hydrogen-cooled synchronous condensers which are built to meet applicable N.E.-M.A., A.S.A. and A.I.E.E. standards. There is a listing of standard features of these units and a description of the electrical and mechanical construction details. Exciters, auto-transformers for starting, and starting motors are also discussed in the bulletin.

Water Solids Content

A quick and simple method for determining the solids content of boiler water or condensate is described and illustrated in Bulletin 2RE50 issued by Hall Laboratories, Inc. The bulletin mentions an ingenious method of utilizing a cathode ray balance indicator which permits almost instant determination of the proper dial setting.

Chlorinizer

Builders-Providence, Inc., has made available Bulletin 840-G27 which describes the high-capacity, visible-flow Model HCVS Volumetric Chlorinizer. In addition to a cutaway drawing and a diagram showing operation, the bulletin contains a discussion of safety features, maintenance costs and installation.

Piping Progress

"One Hundred Years of Piping Progress" is the title of an attractive 32-page brochure commemorating the 100th anniversary of the Grinnell Corp. Following a section highlighting the history of the company there are illustrations of current plants and warehouses, typical products and customers, and research facilities.

Soot Blowers

Bulletin 484 issued by the Vulcan Soot Blower Division of Continental Foundry & Machine Co. is a 24-page attractively illustrated brochure showing typical soot-blower installations in recently constructed central stations.